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Problems of Illumination.

A valued correspondent in commenting elsewhere in this issue upon a recent editorial on the engineering side of illumination, makes a plea for more practical and concrete consideration of the illumination itself apart from ways and means. There is much to be said for this point of view, and yet illumination as an art has been, and for that matter still is, in so unappreciated a state that an immense amount of preliminary work has to be devoted to organization of the fundamentals. Consider for a moment how in everyday practice a building is lighted. It is usually planned as a structure by a competent architect whose entire training has been concerned with artistic and structural matters and who too often forgets that artificial lighting is more than a secondary or tertiary consideration to be decided after all the details of construction and finish are attended to. The wiring specifications are often sketched out by a clerk in the architect's office whose knowledge of electrical matters is negligible, and are practically left in the hands of the contractor with an injunction to make as low a bid as he possibly can. Sometimes merely the number of outlets per room is indicated, or again outlets are located practically where they look symmetrical upon the plans, without the slightest reference to their suitability.

The contractor is too often innocent of any special skill in illumination and does the cheapest thing he can with the specifications. The result one can see almost anywhere. There are plenty of cases in which the architect apparently did not care, and certainly did not know, whether the light would be good or not, provided the fixtures fitted an early Flemish or some other second-hand idea of artistic effects. For example, there was a school-house of majestic proportions in which the architect provided just two 16-c.p. lamps, placed 10 ft. high, for each room of about 1,000 sq. ft. area. An artist of another sort lighted a large public room by a row of bare incandescents placed exactly in the plane of vision. A third of the same species lighted a high hall with a single huge chandelier 15 ft. from the floor, and well nigh raved when the use of distributing shades was suggested. Now, when one has to deal with this kind and volume of popular ignorance, the dissemination of accurate knowledge as to illumination measured in foot-candles or other appropriate units is simply a waste of breath. The first necessity is a sort of kindergarten educational program, entirely needless for well-informed engineers like the correspondent whose protest appears on another page, but absolutely imperative in getting the public, who have been led mainly by the blind, to realize what lights really are for, how they can be installed and used and measured, and what economies can be effected by proper design.

Moreover, one cannot establish a standard of illumination, which is the effect, without a standard of luminous intensity, which is the cause. There is, therefore, a formidable task before illuminating engineers in settling these really fundamental questions. The Illuminating Engineering Society has had its energies taken up in a campaign of education which has not been fruitless. It has now begun to take up, through an international committee which will co-operate with other engineering bodies, the question of standards, thus clearing the way for the definite work which the correspondent very properly considers important. But the preliminary work is necessary. It is of little use to promulgate the fact that a school-room requires 30 luces on the working plane and a drafting-room 60 luces, when there is no general connection defining a lux, no generally legalized standard of light and utter indifference on the part of a large section of the public as to whether it gets the amount specified, provided its bills are small enough. When people come generally to realize that one 16-c.p. lamp properly placed and shaded will do the work of two or three improperly installed, and that such a saving is thoroughly practicable, and when they realize, too, that the planning of illumination is a special branch of expert knowledge concerning which the opinion of the untrained architect or wiring inspector is of little more value than that of a glazier or a horse-doctor, illuminating engineers can devote their time to the peaceful accumulation of valuable data. In point of fact, there is a large mass of practical data already published, although considerably scattered, as is generally the case in the early growth of a new art.

Developments in Pile Foundations.

The construction of pile foundations is probably among the oldest of all engineering works, and yet it has not even at this time passed the point where developments of the highest importance in connection with it may not be made. Obviously there can be but little opportunity for new extensions or applications of timber piles for foundation purposes except possibly in the direction of submitting them to processes which add materially to their durability and to their capacity to resist the attacks of marine worms. In localities where timber grows in suitable lengths and sizes for the deeper and heavier class of foundations, anything which gives to it added life or increased resistance to any destroying agency will add much to the structural value of piling. Developments of this character are obviously modern and include the well-known preservative processes of more or less value and such procedures as protecting piles with shells of tile, concrete or other similar material to render them proof against the attacks of the teredo. While these procedures have certainly enhanced the value and durability of timber piles in many localities where it would be impossible to use timber without some such protection, they are far from being generally applicable, and in many cases are too expensive to be seriously considered. While it is a little dangerous to act the part of a prophet as to the future of timber piling, it seems to be fairly safe to state that there is little promise in the near future of much development of real value beyond present conditions.

On the other hand, when attention is directed toward a change of material for pile work, either for foundations or for cofferdam enclosures, there is a reasonable prospect of much development. It may be a question whether the many ingenious forms of steel sheet piling will find general application, although they have shown admirable efficiency for special purposes under circumstances where the duty which they have performed has been severe. In work of a more or less temporary character the matter of corrosion is not serious and may be entirely neglected, but whether the same observation can be applied to piles for foundation purposes where permanence is a prime requisite is another question. It is true that iron piles, both cast and wrought, have been used for such works as ocean piers with more or less satisfactory results, but on the whole those special works can scarcely be classed as satisfactory and durable for most permanent water front structures. It would scarcely be proposed, for instance, seriously to consider iron piles as a substitute for those of timber which are so widely used for the heaviest dock and pier work on the water front of Manhattan Island.

The application of concrete, plain and reinforced, to the construction of piles has, however, a number of features which cannot fail to possess much interest in connection with subaqueous foundations and other similar structural work. It may perhaps be urged with much reason that experience with this class of piles, of which the types are already numerous, has not been sufficient either in time or variety of service to place them beyond the experimental stage. This is undoubtedly true in many respects and perhaps in most respects. At the same time much interesting work has been accomplished with them.

It is no part of these comments to consider any special types of concrete piles, but rather to mention their possible developments and applications as a class. In the first place it is clear enough that any really permanent pile may cost materially more than its timber counterpart, and still be more economical if the cost is not too nigh. Real economy will control this class of construction as it does every other, irrespective of other considerations. It would appear to be feasible to produce concrete piles at a cost to bring them within the range of competition for the works to which they are adapted. Whether they can be made and driven with a quality and price suited to sheet piling work, except in some special cases, is yet an open question. Indeed such an application of concrete piles has been made in but few cases, although there seems to be no reason why they should not be adapted to that work provided the cost is not prohibitive. They certainly can be molded in almost any desired form and they can probably be put in place almost anywhere by the aid of pilot piles if necessary.

One marked advantage of concrete piles in many locations will be their immunity from those attacks of decay, molluscs and insects, which destroy timber so readily, and the corrosion which militates against the life of iron or steel piles not with the same rapidity, but with practically the same certainty. It may be doubted whether the reinforcement will hold indefinitely under some conditions, but it is believed that with increased experience with reinforced concrete work it will be found possible to fabricate the concrete in connection with the embedded steel so as to protect the latter from corrosion for an indefinitely long period of time. Where it is necessary to finish the tops of piles at an accurate elevation like those sawed off under water for pier foundations, the application of the reinforced concrete pile might be attended with some trouble, but there are various methods of overcoming even this difficulty to which resort may some time be made. At any rate the stiffness against bending of the reinforced concrete pile, the permanence of the concrete and the high carrying power which may be given to the combination, make the eventual development of this class of piles a matter of interesting engineering consideration.

Tests and Shop Records.

In the broader studies of equipment performance which characterize the work of operating engineers on well-conducted railroads and other large industrial systems, the value of special tests of capacity and efficiency is well recognized, but the relation between test results and shop records is frequently overlooked as a possible source of valuable information. The analysis of test and shop reports taken together, including, of course, regular records of the behavior of apparatus in service, should be the basis of many decisions as to the fitness of any given types of equipment for specified conditions of operation.

These questions of adaptability demand accurate technical knowledge of the essential features of any equipment whose status is indeterminate, but above this requirement in importance is the power of drawing sound conclusions as to the general excellence of the design, the ability of the equipment to withstand severe conditions definitely stated, the tendency of apparatus to lie idle on account of minor repairs, the cost of maintenance in relation to the service performances, and the probable rate of depreciation. Well organized tests will throw much light upon the intrinsic economy and capacity of equipment; well-kept shop records will present convincing evidence of the wear and tear in actual service, and the two together will go far to establish or disprove the claims of the manufacturers that this or that piece of machinery is the proper design for the conditions, so far as those conditions are stated.

In many instances these two sets of supplementary data are not combined, and the result is a series of haphazard decisions that cost the operating company considerable money. The expense of operating a system with misfit equipment is often entirely unrealized. It may not be, and probably seldom is, the fault of the manufacturer that the apparatus selected for the service is incapable of handling the business at the lowest total cost which good engineering postulates. There is obviously a limit to the amount of so-called free engineering which a manufacturer can be expected to perform for the prospective purchaser, and the tendency of the latter to fail to state all the essential conditions in asking for bids is altogether too frequent. The selection of motors for railway service illustrates how urgently definite information as to probable operating conditions is needed, and how much depends upon the proper tabulation of schedule requirements, stops per mile, car weight, speeds and track constants. In this particular field the manufacturer probably knows better than anyone else just what each size of motor is capable of doing, but it is only the test of service which proves the long-run economy of the selection. Into this test of service must enter the experimental study of the equipment's behavior under severe conditions, the performance in definite service and the life and maintenance records as gleaned from the shop files. First cost and the fixed charges developing from it are the final data which should be thrown into the balance pan in weighing the permanent merits of selected designs.

Imperfect shop records or the failure to preserve itemized data of the cost of repairs and renewals mar the accuracy of decisions bearing upon the selection of equipment. Desirable as it is to spend money upon tests, it is even more essential that the auditing departments of great industrial organizations draw into closer touch with the shops. Observation of conditions in the atmosphere of machine tools and conversation with progressive department heads are worth all that they cost in half-hours away from the adding machine and the loose-leaf ledger. When an organization is administered on the basis of combined rather than separate executive and analytical duties a long step has been made toward commercial success. The fitting together of test and shop records is a worthy illustration in detail of such a policy.

New Experimental Data Concerning Reinforced Concrete.

Most engineers have been aware that important tests were conducted during 1906 at the University of Illinois Engineering Experimental Station to ascertain the behavior of plain and reinforced concrete columns and reinforced concrete T-beams under stress. The results of these investigations under the direction of Prof. A. N. Talbot have recently been published by the University in two bulletins for free distribution and therefore need not be reviewed at great length in this journal. The results and Prof. Talbot's analysis of them all tend toward the conservative design of structures of reinforced concrete and accordingly deserve hearty commendation. Many of the values of the strength of concrete used to-day in design were obtained by experiments with small test specimens of the best materials prepared so that the character of the specimens was undoubtedly higher than that of the average concrete used at the present time. Moreover, the specimens have generally been small and tests made on specimens of this sort usually give higher values than those on larger specimens, owing to the restraining effect of the bearing plate of the testing machine. It must be admitted, therefore, that safe practice makes it desirable to select low working stresses in designing concrete, particularly as the chances are that some of the members are not so well made as others, and consequently all of them will not carry the loads for which they are designed. Slight settlement and other distortions which are not very large in amount will also affect the distribution of stress, so that Prof. Talbot is entirely justified in sounding a note of warning against the use of high working stresses under ordinary cases.

Seventeen columns were tested and Prof. Talbot points out that the results are published simply as indications of the direction in which further experiments will be likely to yield useful returns. The columns were made of limestone from ¼ to 1 in. in size, containing 54 per cent. of voids; sharp, well-graded fairly clean sand containing 28 per cent. of voids and Chicago AA Portland cement; these materials being mixed 1 : 2 : 3¾, measured by loose volume. The columns were 6, 9 and 12 ft. long and 9 and 12 in. square. Some were plain, some reinforced by a ¾-in. mild steel rod at each corner and the remainder by similar vertical steel rods tied horizontally at intervals. In addition cubes and cylinders of concrete were prepared for small size tests. The longitudinal deformation of the columns was read by means of an extensometer devised specially for the tests. The columns were tested by applying the load in increments of about 10,000 lb. In six cases the load was increased progressively until failure occurred, and in ten cases the load was released at one-third to two-thirds of the ultimate, and then reapplied. In one case the load was released twice. The relative amount of load taken by the concrete and by the steel was determined by means of the observed relation between loads and deformations under the assumption that the stress in steel reinforcement is proportional to the deformation in the column. This also assumes that the bond between the steel and concrete is adequate. On these assumptions the average maximum stress in the concrete for the reinforced columns was found to be 15 per cent. less than the average for the plain concrete columns. While this result is not necessarily applicable to all cases, and may be incidental to the columns used or the methods of testing, most readers will agree with Prof. Talbot that it is an added reason for caution in choosing working stresses for this type of construction.

The portion of the report which will most interest experienced designers of reinforced concrete relates to the diagrams representing the relations between the loads on the columns and the corresponding deformations. These diagrams show a variable relation well expressed by a parabolic curve, as is also the case with tests made at the Watertown Arsenal and quoted by Prof. Talbot. The tangent to the parabola at the point of no load represents by its slope the initial modulus of elasticity of the concrete and forms a convenient basis for an expression of the variable relations between stress and deformation. The analysis of the curved stress deformation diagram given by Prof. Talbot deserves careful attention, for it is the present practice of a good many engineers to consider that, for working purposes, the modulus of elasticity of concrete is a constant. Prof. Talbot holds the contrary opinion, and believes that the data furnished by his tests and those at the Watertown Arnesal indicate the advisability of using a curved relation in the class of reinforced concrete generally employed in structures. He definitely states, however, that his discussion of the subject must not be considered as committing him to the position of excluding the straight line stress deformation relation from use in any formulas or their application. While a constant modulus may be entirely safe for calculating the strength of beams with a low percentage of steel, the tests certainly indicate that it may be decidedly misleading for beams having a large amount of reinforcement. The average value of the initial modulus of elasticity in the case of the columns tested at the University of Illinois is 2,250,000 lb. per square inch, and in the case of the Watertown Arsenal columns, 2,500,000 lb. All of the tests in the two laboratories mentioned show that the modulus falls off, so it is suggested that when designs are based on a constant modulus the value chosen should be less than that for the initial modulus. Prof. Talbot states that further data on the effect of the age of the concrete and the repetition of loads upon the modulus are necessary before definite conclusions can be reached.

Another matter which he believes should receive more attention than is usually given to it is the basis for working factor and working stress. The conditions of loading, of transmission and distribution of loads, of variation in fabrication, all act to make the stress actually developed in a member of a structure greater than the assumed working stress. For steel the real basic point is the elastic limit or yield point, and for concrete Prof. Talbot believes that this basic point may be considerably below the ultimate strength. He suggests the choice of a value corresponding to a deformation equal to one-half of the deformation at the point of failure, which, by the parabolic relation, is equal to three-fourths of the ultimate strength. Having selected a basic point, a working factor to obtain the working stress may then be chosen to cover contingencies, emergencies and variations in the distribution of load and quality of materials suitable for any given case. The range in values for the working factor which may be used with concrete is, of course, much greater than with a material like mild steel.

The tests of reinforced concrete T-beams are of interest on account of the light they furnish concerning ordinary floor construction. The most important fact brought out is that the maximum strength of such members to resist horizontal tension and compression may be calculated satisfactorily by the ordinary methods and formulas for rectangular beams, considering the enclosing rectangle of the T-beam to be the equivalent rectangular beam. Prof. Talbot finds that this approximation is at least applicable for reinforcement not exceeding one per cent. of the enclosing rectangle. It gives little error when the thickness of the flange is at least one-quarter of the depth of the beam, and the width of the flange not more than four times the width of the stem.

Enough has been stated to indicate in how many ways Prof. Talbot has opened up interesting fields for experiment and speculation. The character of the tests made at the University and the fact that many of the results obtained there can be checked by previous large scale investigations at the Watertown Arsenal make the information derived from the experiments of more than usual value. Prof. Talbot deserves the hearty thanks of the engineering profession for the labor he has spent in analyzing all the data at his command and stating it in detail in these bulletins which the University is distributing gratuitously to engineers.

Notes and Comments.

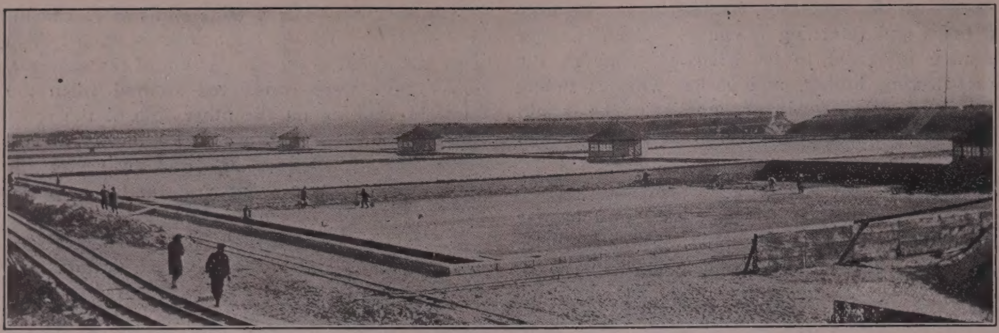
THE PORTO RICO RAILWAYS have recently been examined by Mr. James Peabody, of Chicago, at the request of ex-Governor Winthrop, and his opinion of them is not very high. The chief line is a narrow-gauge road about 200 miles long connecting San Juan, Ponce and Carolina. It is capitalized at $16,000,000 but its earnings have been absorbed by operating and administration expenses. About four-fifths of the business is hauling sugar cane at ridiculously low rates in most cases. An instance mentioned was a charge of 80 cents for hauling a car of cane 8 miles and returning it empty. The passenger service is stated to be wretched, none of the cars having brakes, and pocket whistles taking the place of bell cords for signaling. The freight cars have brakes, but they can be set only from the ground.

THE AULD BRIG O' AYR, made famous by one of Burns's poems, was built many centuries ago, for the charter of the burgh of Ayr, granted in 1236 refers to it. It has been repaired many times, but in 1903 was reported to be so unsafe that its longer existence was unlikely. The city would eventually come into the possession of a bequest for repairing the structure and was accordingly on the horns of a dilemma between the invalidation of its prospective right to this bequest by carrying out the work for which the money was intended or running the risk of the collapse of the bridge. Fortunately the necessary funds have been collected privately and the repairs have been started under the direction of Messrs. Simpson & Wilson, the well-known Glasgow engineering firm. According to an article in "Engineering" the work will be done by injecting Portland cement grout into all parts of the structure. It consists of four segmental arches of approximately 53 ft. span and 18 ft. rise, with three river piers 15 ft. thick having heavy cutwaters on both ends. The piers rest on a grillage of oak logs only a few feet below the river bed, a fact discovered during repairs to the foundations a number of years ago.

THE RAILROAD WRECK in New York on Feb. 16, when 24 people were killed and 143 injured has been investigated by the New York State Railroad Commission, which has reached the following decision: "1. That the accident was caused by a condition of weak track, which was discovered and reported by the engineer of train 5, which left the Grand Central Station on the morning of Feb. 16 at 9.03 A. M. Also that this bad spot became worse by reason of the pounding it received from numerous passing engines, holding, however, until subjected to the unusual and abnormal pressure exerted by the impact of the two powerful electric locomotives running at a very high rate of speed striking it in quick succession, shearing the spikes and causing the rail to spread. The accident, therefore, was the result of a track condition, plus speed, plus again the neglect to locate and remedy conditions that had been reported on the morning of the accident. 2. The board is further of the opinion that on the day of the accident in question no trains should have been allowed to run over the Harlem division on track 3, even at their schedule rate, until the track supervisor on that division had reported affirmatively to the superintendent or the general manager even that the track in question was right in every respect. The testimony adduced by the board fails to show that any such affirmative report was made, and the officials of the railroad when given an opportunity to offer evidence on this subject likewise failed to produce any testimony to that effect."

THE BRACING OF VAULTING like that forming the roofs of filters is a very important matter, which receives some prominence through the recent collapse of part of the roof of the Lawrence filter. It first received general attention in this country through the collapse of the roof of the Wellesley reservoir in 1897. The failure of this roof led Mr. Allen Hazen, who was then preparing specifications for the covered filters at Albany, to insert a clause in the specifications to the effect that no centers should be struck without the express consent of the engineer, nor until the walls on all sides of the filters were completely secured. The outside walls were considered secured when the embankments against them were completed to the satisfaction of the engineer. Cross walls were considered secured when the concrete vaulting on the other side of the cross wall for the entire width of one filter was in position and set, whether supported by centers of not. This requirement proved too hard on the contractors, but the experience gained at Albany indicated that something of the sort was essential, and accordingly, when the specifications for the filters at Washington were prepared in 1903, a clause was inserted in them similar to that of the Albany requirements except so far as the cross walls were concerned. These were considered secured when the concrete vaulting on the other side of the cross wall for at least two sections was in position and set, whether supported by centers or not. In recent work executed from Mr. Hazen's plans, the clause relating to this subject reads as follows: "No centers shall be struck without the express consent of the engineer, and subject to such conditions as shall secure the safety of the work." Under this clause Mr. Hazen has usually ruled that two bays of vaulting, completed and resting on centers beyond the centers to be removed, were sufficient to secure the work. Attention is called to this matter because there seems to be a natural tendency among contractors to remove the centers of vaults before it is safe to do so.

THE REPORT ON THE FOUNDATIONS for the Panama Canal locks which is printed in the Current News Supplement of this issue is a document which leaves the Isthmian Canal Commission entirely free to go ahead with the construction of a lock canal, so far as criticisms of the site of the locks are concerned. The report is signed by a past-president of the American Society of Civil Engineers who has been connected with foundation work through most of a long and highly successful career, by another past-president of the American Society of Civil Engineers, who has achieved distinction as a specialist in waterworks construction, and by a former vice-president of the American Society of Civil Engineers who has been connected in responsible capacities with many important hydraulic undertakings. The three men who have signed this report have been signally honored by the national civil engineering society, and the Government is accordingly warranted in holding the opinion that if these men cannot advise it correctly concerning the site for locks, then there is no use turning to engineers who have not been so highly honored by their own colleagues. Admitting that the report is a full justification for the Administration's determination that the foundations are sufficient for the great works to rest upon them, the fact remains that a good many engineers who have seen samples of the material which the report describes as fine-grained bluish gray rock are not so firmly impressed with its suitability for the proposed purpose. This journal is of the opinion that any further discussion of the matter, however, is of no use at the present time, and that until the site of the locks in each locality has been laid bare, there is no justification in assuming that the government should further delay the construction of the work on the ground of inadequate foundations. It will be noticed that the report states that when this rock is exposed to the weather some of it disintegrates, but that this will not affect its bearing capacity where an excavation is covered with masonry before the material has long been exposed. This characteristic of the material manifestly will make the problem of completing the excavation and starting the concrete work one which will tax the resources of the engineers and those responsible for the direct construction, although it is not insuperable.



Slow-Sand Filters of Osaka Water-Works.

NOTES ON WATER FILTRATION IN JAPANESE CITIES.

By George A. Johnson, Assoc. M. Am. Soc. C. E., Principal Assistant Engineer with Hering & Fuller, New York.

Time was when all Japanese water works consisted of pails suspended from either end of a bearing pole on the shoulders of a trotting coolie, but in a number of cities these primitive methods have been supplanted by modern works embracing not only well equipped and efficient pumping outfits, but well built and well operated filtration works, among which probably the most noteworthy are those of Tokyo, Yokohama and Osaka.

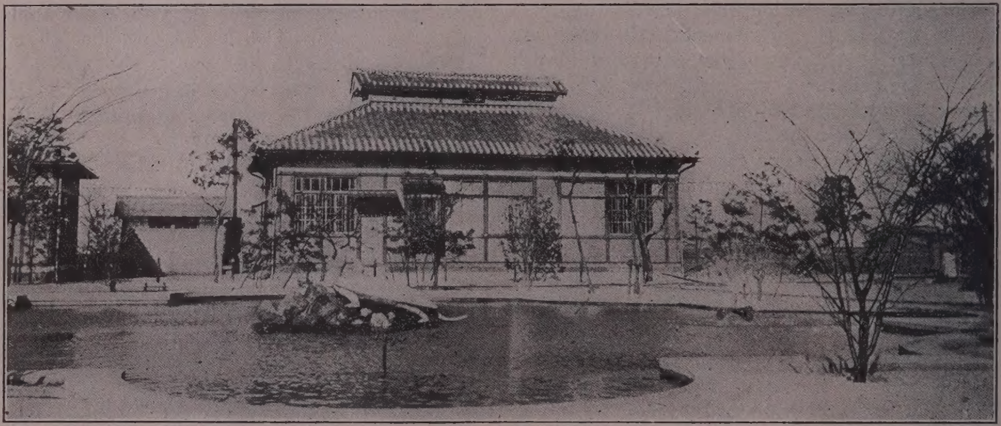
During the writer's recent visit to Japan it was his good fortune to meet many of the leading men in charge of important engineering work there, and from them to learn much of the rapid advances which are being made in that country in municipal sanitation. Among those to whom the writer is particularly indebted and desires to record his thanks are Dr. Y. Nakajima, of Tokyo; Mr. Zentaro Mita, of Yokohama; Mr. S. Inoue and Dr. S. Tanabe, of Kyoto; Mr. K. Funabiki, Mr. K. Inouye, Mr. H. Ono, Mr. S. Odawara and Mr. Y. Tsujimura, of Osaka.

Tokyo Water Works.—The first municipal system of water works was built at Tokyo, the present seat of the Japanese Government. Following his great victory at Sekigahara in 1600, Iyeyasu, founder of the Tokugawa dynasty of Shoguns, who were the virtual rulers of Japan for more than 260 years, selected Tokyo as his capital and inaugurated the first Japanese public water supply. The history of these works has been stated by Dr. Y. Nakajima in articles published in the Japanese engineering journals, and the following notes are from translations of these articles made for the writer by Mr. Nakata, of Kobe.

Owing to the fact that most of the ground upon which Tokyo now stands was under cultivation at that time, the well waters in and about the city were rendered unfit for domestic consumption. Also on account of the proximity of Tokyo to the sea these well waters were rendered unpalatable through tidal influences. This latter was probably one of the main reasons why Iyeyasu set on foot the movement to provide his capital with a new and public supply. The water supply introduced by Iyeyasu was derived partly from rivers and partly from small nearby ponds, and was brought into the city through open canals. Some of these sources, particularly the rivers, were more or less polluted, and the supply, during the first years of its existence, was unequal to the demand.

About 240 years ago, or some 65 years following the inauguration of the original works, the source of supply was changed to the Tama River, the source of the present water supply of Tokyo, and a more adequate system was constructed. Distribution was effected by canals and conditions so greatly improved that each engineer in charge of the work was given a thousand bushels of rice and had his name changed to Tamagawa. In the new system there were about 25 miles of canals and about 2¼ miles of closed conduits. In the city there was about ¼ mile of open canal and iron and wooden distributing pipe to the extent of about 55 miles.

The Tokyo of the present day has a population of about 1,500,000 and with its many broad, well-kept streets, stately government buildings, and beautiful parks is *facile princeps* among all Japanese cities. The water works, located at Yodobashi on the western outskirts and about 4 miles from the heart of the city, were finished in 1898. A description of the Tokyo water works by Dr. Nakajima is contained in the "Proceedings" of the American Water Works Association, 1905, and some of the data contained therein are incorporated in this article, acknowledgment of which is hereby made. The design called for a capacity of 45,000,000 gal. per day, and it is the opinion of Dr. Nakajima that with a few small additions the system will prove to be of adequate capacity until the population reaches 2,000,000.



Laboratories of the Osaka Water-Works.

The intake is located on the Tama River at Hamura about 30 miles above the city, and the old canal, about 25 miles long, which has delivered the supply from the same point for over 240 years, is still in use. This canal has been extended to the Yodobashi works, about 2½ miles east of the terminus of the old canal. With the exception of a stretch of about ⅘ mile from the present works, the canal has earth walls and bottom. The short section near the works referred to is lined with concrete. From the inlet to the outlet end of the canal the fall is about 300 ft., or roughly 10 ft. per mile.

On the occasion of the writer's visit to the works the raw water was particularly free from color and contained not more than 20 parts per million of turbidity. The average alkalinity of the raw water is about 20 parts per million. The watershed is about 200 square miles in area and quite extensively used for agricultural purposes. For this reason the water becomes very muddy during the rainy season, the periods of muddiest water lasting about two weeks at a time on an average.

As to the treatment of the raw water, upon its arrival at the works it is led into continuous-flow settling reservoirs through an open, concrete-lined canal, and a period of sedimentation of about 36 hours allowed. The clarified water is then applied to slow sand filters. From the filters it flows to covered filtered water reservoirs, whence it is either pumped or flows by gravity to the city.

The settling reservoirs are three in number, each 720x360x19.5 ft. average depth. Each has an effective capacity of 22,440,000 gal., or a total effective capacity of 67,320,000 gal. The slope of the floor in each basin is 1 in 720. At a water consumption of 45,000,000 gal. per day the period of sedimentation in these basins is equal to about 36 hours. Under these conditions the velocity of flow is about 0.067 in. per second.

At a point on the main supply canal just before the water reaches the settling basins, potash alum is applied at times when the suspended matter in the raw water is high. The coagulant is added to the water in liquid form through a perforated pipe extending completely across the canal, and at about mid depth. It is said that the periods of muddy water during which it is necessary to make use of the coagulant amount to a total of about 30 days in the average year. The amounts used average about 1.2 grain per gallon. The coagulant is made in Japan, and costs about $30 per ton delivered at the works.

From the settling basins the water flows through inlet regulators to the sand filters, of which there are eighteen. Each filter tank is 258x168x9 ft. deep. The total filtering area is, therefore, about 18 acres. At the bottom of the filters there are two layers of brick set on the side, which serve as effluent collectors. Over these is a 24-in. layer of graded underdraining material surmounted by 30 in. of medium fine sand.

When in operation the depth of water over the sand surface amounts to about 33 in. There is a weir gauge on the outlet of each filter. The rate of filtration fluctuates somewhat, but averages about 9 vertical feet per 24 hours, or 2,933,000 gal. per day. The total daily gross capacity of the eighteen filters is thus 52,794,000 gal.

The filters require scraping seven times a year on an average. The material removed at these times is dumped into cement-lined troughs, water applied and the dirty sand agitated with rakes until clean.

There are three filtered water reservoirs located respectively at Yodobashi, Hongo and Shiba. The capacity of each reservoir is about 7,500,000 gal. Figured on a daily consumption

Removing Sand from Deeply Clogged Bed, Osaka.

Transporting Dirty Sand from Bed, Osaka.

of 45,000,000 gal., this provides exactly 12 hours' storage. All of these basins are covered.

The city is divided into two districts, high and low level, respectively, the population of the latter being about twice that of the former, which is supplied by direct pumpage from the Yodobashi station. This district includes all parts of Yotsuya, Akasaka and Azabu wards and the higher portions of Shiba, Kojima Chi, Ushigome, Koishikawa, Hongo and Kanda wards. The remainder of the city is supplied by gravity from the branch filtered-water service reservoirs at Hongo and Shiba.

During the year 1904 the maximum daily water consumption was equal to about 35,000,000 gal.; the minimum, 18,500,000 gal.; and the average for the year about 25,000,000 gal. These figures correspond to per capita daily consumptions of about 23, 12 and 17 gal., respectively.

The Yodobashi pumping station contains four 300-h.-p. pumping units, each of a capacity of 7,500,000 gal. per 24 hours. The working head ranges from 80 to 100 ft. The boilers are of the Lancashire type and are twelve in number. There are two sets of Green economizers.

There are 407 miles of mains ranging from 4 to 44 in. in diameter; 235 district meters and 20,566 smaller meters. The total cost of the works to date is about $4,130,000.

As to water rents, the charge for one faucet for a house containing five persons is $2.50 per annum, and $0.25 for each additional person. Poor families unable to afford a house connection and taking water from a street hydrant are supplied with a key and charged $0.75 per annum. Where meters are used the charges are $0.063 per 1,000 gallons for users of 20 cubic meters (5,284 gal.) per month, and $0.015 for each extra cubic meter. For public baths the charge is $0.0375 per 1,000 gal., and for sprinkling, $0.095 per 1,000 gal.

Yokohama Water Works.—Yokohama, situated but 17 miles from Tokyo, is the main seaport of Japan at the present time, although its leadership in this field is being sharply contested by Kobe, the seaport of Osaka, the leading commercial center of the Mikado's empire. In 1859, five years after the first treaty with the United States was signed, Yokohama was declared an open port, thereby becoming the pioneer Japanese city in this respect.

The present population of Yokohama is estimated to be about 330,000. Of this number about 10,000 are of foreign birth.

The water works are situated on the western outskirts of the city, on a hill, Nogiyama no ura, about 160 ft. above sea level and 150 ft. above the average street level. The source of the supply is the Doshi River, on which the intake is located at a point near the foot of the peerless Fujiyama and some 30 miles from the city. It is a gravity supply throughout, the water being piped to the works on Nogiyama, where it is filtered through slow sand filters and afterwards distributed by gravity to the consumers.

The raw waters of the Doshi River were remarkably free from color and turbidity at the time of the writer's visit to the works in the early part of 1906. Following heavy rains, however, the raw water is said to be quite muddy, presumably on account of the considerable proportion of the watershed which is almost continually under cultivation. The extent of pollution is said to be merely nominal, although owing to the fact that here, as everywhere in Japan, all human excrement is carefully preserved for fertilizing purposes, it might well be expected that the possibility of serious pollution would be imminent at times of heavy rains.

The filtered water, on the occasions of the writer's several visits to Yokohama, was of excellent appearance at all times and stands in enviable repute among the citizens of that city. It has an alkalinity of about 27 parts per million.

On reaching the filtration works the four supply mains discharge into two inlet wells of masonry construction, from which the water is distributed to the filters. These wells are small and permit of comparatively no storage. Suitable regulating appliances are provided to maintain a constant water level in the wells and on the filters.

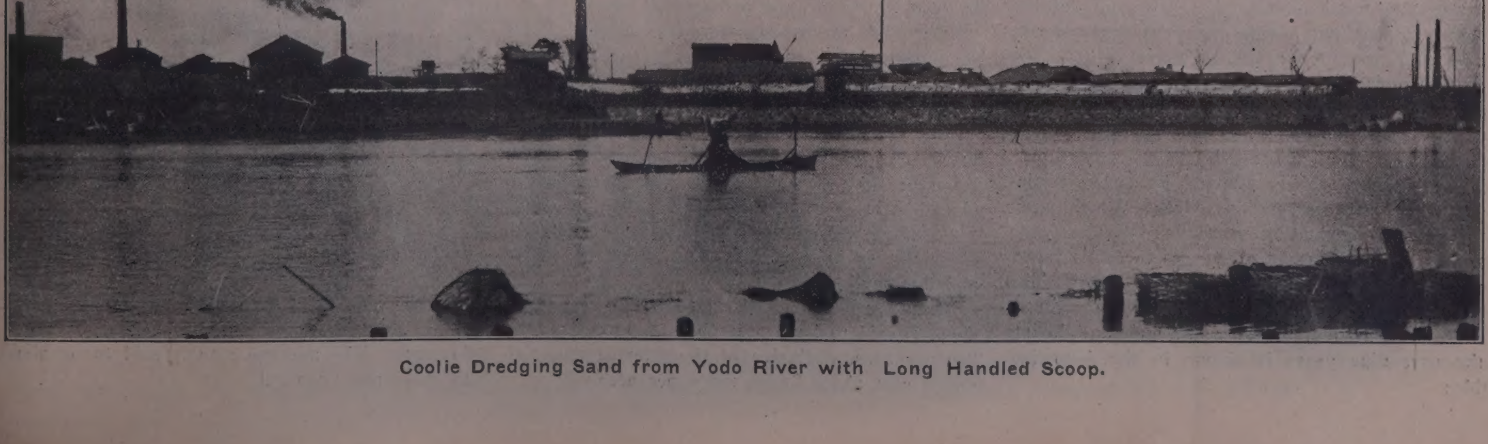
There are six slow sand filters in commission at this time, three of which were built 21 years ago, at the time the first pipe lines were laid from Fujiyama. Since that time the remaining three have been constructed, the last two having been completed only last year.

The filters are arranged in two batteries, one of four beds and one of two beds. The former are each 120x70 ft., equal to a total of 0.771 acre in actual filtering area. The latter are each 120x80 ft., equal to a total filtering area of 0.441 acre, making a combined area for the six filters of 1.212 acres.

The filter tanks are of masonry and brick and are well built. For effluent collectors there are two layers of brick laid flat. Over these are laid 18 in. of graded underdraining material which supports a layer of medium size sand 2.5 ft. in thickness. This sand is obtained from the beach, is rather dark in color, but apparently of good, stable quality. It costs about $2.75 per cubic yard in the filters. This is somewhat high for filter sand in Japan, and is made so by the expense of transportation from the beach up the hill to the works.

There are no settling basins provided, owing, it is said, to the comparative absence from the water of high amounts of suspended matter except during the rainy season in June, July and August.

The filters are operated at the somewhat high rate of 20 vertical feet, or 6,530,000 gal. per acre daily. The depth of water over the sand when the filters are in operation ranges from 2 to 3 ft. On an average it has been found necessary to scrape the filters about once a month, the periods between scrapings being naturally somewhat shorter than usual during the rainy season. The sand removed during scraping operations is washed in concrete bins about 18 in. deep, the

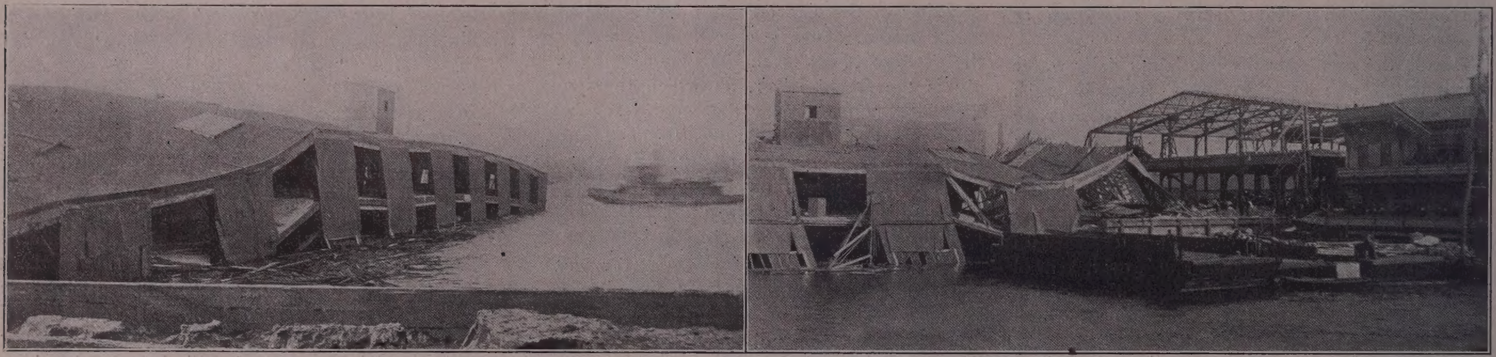


Coolie Dredging Sand from Yodo River with Long Handled Scoop.

dirty sand being dumped into the bins, a stream of water applied, and the sand agitated by coolies with rakes until it is clean.

There are two baffled filtered water basins, one of five compartments and one of nine compartments. The smaller basin is built of masonry and the latter of brick. Both basins are covered with a wooden building about 3 ft. high at the eaves. The roofs are of corrugated iron. The capacities of these basins are 396,000 and 2,796,000 gal., respectively, giving a storage of practically 12 hours' supply.

Osaka Water Works.—Osaka, "City of a Thousand Bridges," the leading commercial center and sometimes called the Venice of Japan, is located in Osaka Prefecture on the coast and at the northern extremity of the Izumi Sea. Historically as well as commercially, Osaka stands prominently forth among Japanese cities. It was one of the six ports first thrown open to the commerce of the world. Yokohama, Nagasaki and Hakodate were declared open ports in 1859, five years after Perry's treaty was signed. In 1868, following a period of violent civic commotions which culminated in what is known as the "Restoration," the ports of Osaka and Kobe were opened, and during the following year those of Tokyo and Niigata.



View of Outer and Shore Ends of the Wrecked Pier at Baltimore.

At Osaka the first Japanese mint was established in 1871, and here is located the famous Osaka Castle, within the walls of which is the present distributing reservoir of the water-works system. This castle, once a Buddhist monastery and stronghold, was destroyed by Ota Nobunaga in 1580, rebuilt by Hideyoshi about ten years later, and since destroyed many times. It is now used as a government arsenal.

The present population of Osaka is estimated at 1,200,000, and the water consumption at about 22 gallons per capita daily. The actual daily water pumpage at present ranges from about 15,000,000 gal. in the winter to about 23,000,000 gal. in the summer. The heaviest pumpage is usually in July and August, and the lightest during January and February.

The source of the city's water supply is the Yodo River, from which the water is raised by three centrifugal pumps to a series of settling reservoirs against a total head of about 30 ft. The ordinary suction lift is about 14 ft. The combined capacity of these pumps is said to be about 35,000,000 gal. daily. The water is allowed a period of about 36 hours' sedimentation on an average and is then applied to slow sand filters. The filtered water is pumped by seven triple-expansion pumping engines of the Worthington type to the distributing reservoir at Osaka Castle against a total head of about 130 ft. This reservoir has a capacity of about 3,750,000 gal. The supply to the consumers is entirely by gravity.

The rate of increase in water pumpage during the past nine years is shown in the following table:

Year.	Gallons per day.	Year.	Gallons per day.
1897	8,500,000	1902	15,000,000
1898	10,000,000	1903	18,000,000
1899	10,100,000	1904	18,800,000
1900	11,600,000	1905	20,400,000
1901	13,300,000		

There are well equipped chemical, bacteriological and cement testing laboratories maintained by the city at the water works, and systematic analyses of the raw and filtered water are made daily by trained analysts. In this connection it is interesting to note that the methods of analysis employed in these laboratories are as a rule well up to date.

The character of the untreated Yodogawa water is much like that of many American rivers. The turbidity ranges from about 10 to 350 parts per million. In an average year there will be about 20 days when the turbidity of the raw water will be over 100 parts per million, and about 50 days when it will be over 50 parts. The alkalinity averages about 20 parts per million, and the numbers of bacteria range from 40 to 30,000 per cubic centimeter and average about 2,000 per cubic centimeter.

There are at present four settling reservoirs in operation, and a fifth is nearing completion. These reservoirs are each 330x360x12 ft. effective depth (the actual depth is 15 ft.), and have a combined effective capacity of 42,600,000 gal. They are worked in series, as before stated.

The sediment is flushed from these reservoirs once annually, when on an average between 3 and 4 in. (or in the neighborhood of 5,200 cu. yd.) are removed. It is said that the cost for labor in removing this sediment is about $100 per year, or about 2 cents per cubic yard.

As to the cost of construction of these reservoirs, the one finished in 1903, effective capacity about 10,000,000 gal. is said to have cost $83,370, exclusive of land which costs at present $2 per tsubo, or $2,420 per acre.

Owing to the unstable character of the ground at the site of the settling reservoirs, the foundations give away at times and cause cracks in the floors and about the corners. It is said to cost about $1,000 per annum to repair these cracks in the four reservoirs. They are built on 18-ft. by 6-in. piles, one pile to every 25 sq. ft.

There are at present eleven slow sand filters in operation, ten of which are 151x182 ft., and one is 182x350 ft. The total filtering area is therefore 7.77 acres.

The filter tanks are built of concrete and brick. At the bottom a layer of bricks on the concrete floor serves as the effluent collector. Over the brick is placed a layer 1 ft. 4 in. thick of coarse, well-graded underdraining material. Over this is a layer 2 ft. 6 in. thick of coarse and fine sand.

The filter last finished, in 1903, 182x350x7.5 ft. deep, is said to have cost about $40,700, or $27,840 per acre, exclusive of the filtering material, which cost about $3,000 more per acre.

Many of the cost items are interesting. For instance, earth excavation is said to cost 9 cents per cubic yard; concrete, $4.50 per cubic yard; piles, 18 ft. by 6 in. in diameter, $0.90 each in place. Cast-iron pipe costs about $60 per ton delivered.

The wages paid to Japanese workmen for 9 hours' work are not exactly what would be termed extravagant, as the following will show: Foremen, 30 cents; brickmasons, 35 cents; stonemasons, 47.5 cents; asphalt layers, 40 cents; mechanics, 32.5 cents; carpenters, 35 cents; apprentices, 20 cents; laborers, 17.5 cents.

The filters are operated in an up-to-date manner. The rate of filtration is not automatically controlled but fluctuates with the pumpage. There is only a very small basin at the works for storing filtered water.

The normal depth of water over the filters is 2.5 ft., and the average rate of filtration is about 9 vertical feet per day, or about 2,900,000 gal. per acre daily. The net yield of the filters equals at this rate about 2,600,000 gal. per acre daily.

Each filter requires scraping about twice a month on an average, and at such times it is said that about one-third inch of material is removed. From November to May the beds are scraped about once a month, and from June to October about three times a month. The scrapers receive 20 cents per day of 9 hours, and the coolies who carry the scrapings from the beds in baskets receive 17½ cents per day of 9 hours.

The scraping operation consumes in all about two days, as follows: 24 hours for draining, 12 hours for scraping an area of about 1.5 acres, and 12 hours for refilling the filter with water. The filter is immediately put back into service after scraping and refilling, and no water is allowed to run to waste.

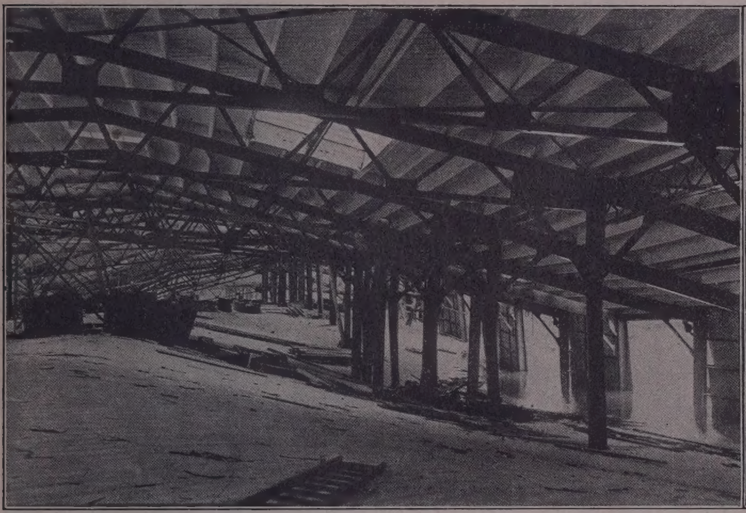
No attempt is made to recover by washing the sand removed during scraping, and it is used for fill. A gang of coolies is kept busily engaged at the river bank practically all of the time dredging and screening sand. The sand is hand dredged from the bed of the Yodo River opposite the water works, is brought to the shore in boats, sun dried and pan screened by coolie men and women. The wages of the men are 17½ cents and of the women 10 cents per day, respectively, for 9 hours' work.

The filtered water is of excellent quality. During the year 1905 the average number of bacteria in the water delivered to the consumers was 25 per cubic centimeter.

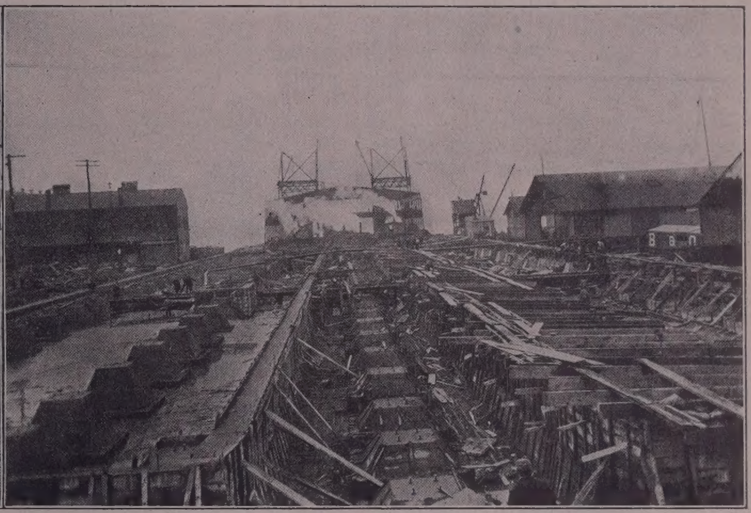
As to water rates, it is stated that the following charges are made per 1,000 gal.: Government and municipal buildings, 10 cents; shipping, 10 cents; military purposes, 20 cents; public baths, 40 cents.; hotels, factories and fountains, 60 cents. The average rate is said to be about 20 cents per 1,000 gal.

The Collapse of the Locust Point Pier, Baltimore.

The Baltimore & Ohio R. R. pier No. 8, at Locust Point in the Patapsco River, Baltimore, was at an advanced stage of construction when it suddenly collapsed at 11 A. M., April 27, killing seven persons and causing a loss estimated at about $400,000. The pier rested on piles and was about 160 ft. wide and 1,000 ft. long and carried a 2,400-ton two-story steel shed, 135 ft. wide, 930 ft. long, and 55 ft. high to the ridge. It had four longitudinal rows of columns carrying the second floor girders, roof trusses and roof beams, and a fifth center row of columns supporting the main second-floor girders only. The exterior columns were battered, and at the time of the collapse the walls were already covered with corrugated iron at the outer end of the pier, where the roof and floors had also been laid, and the structure was practically completed. At the shore-end of the pier, the steel frame-work had been erected but the floors and roof boards had not been laid. The pier forms a part of the company's extensive terminal improvements in Baltimore and was being built at a contract price of $750,000, to provide trans-shipping handling and storage facilities for large quantities of freight. It was to be well equipped with elevators, barrel hoists and four traveling cranes operated by electricity, and with a high-pressure water main for fire protection. It extended about one-half of its length beyond the shore line and on one side abutted against the ends of three old piers which are to be removed after it is completed. It will afford berth space for three of the largest vessels entering the Baltimore harbor and will probably be one of the largest and best equipped piers in the country.



Interior of Shed after Collapse.



Concrete Work on Timber Deck.

The sub-structure consists of over ten thousand 60-ft. piles driven in transverse rows about 4 ft. apart and capped with 12x12-in. timbers supporting a solid course of 8-in. longitudinal timbers at low water level. The edges of this platform support concrete retaining walls about 10 ft. high, and two similar concrete walls a few feet each side of the longitudinal center line of the pier enclose a pit for two depressed standard gauge railroad tracks. The columns are supported on separate concrete piers about 10 ft. high built on the timber deck, with the spaces between them filled with sand on which the first-floor wooden planks are laid. The panels in the side walls were fitted with large doors for receiving and discharging freight, and the roof was provided with skylights. A heavy transverse brick fire wall extended across the middle of the pier.

The water at the end of the pier is about 35 ft. deep, and as for the character of the bottom, Mr. Geo. M. Shriver is quoted in the Baltimore "Sun" as saying that preliminary boring showed 16 ft. of mud, 5 ft. of iron ore and sand, then a deep layer of sand and another of clay reaching to hard bottom supposed to be rock at a depth of 55 ft. Mr. J. W. Richardson, the engineer in charge of sub-structure work, is reported as saying that all piles used were from 50 to 70 ft. long and of unusually good quality, and were invariably driven to a refusal of less than 1 in. with a 2,500-lb. hammer.

The piles were assumed to have a capacity of 20 tons each but were only loaded with 9 tons. All of them were driven to the hard stratum and no settlement was observed in them.

About 10 days before the accident, it was observed that the outer end of the pier was moving transversely eastward and it was closely watched by the engineers and contractors. On April 26 the displacement amounted to about 2½ ft. horizontally and little or nothing vertically. A transitman stationed on an adjacent pier sighted a point on the new pier and kept it under constant observation. Finally the movement increased and he sent warning to the foreman, who ordered the men off from the pier about 10 min. before it collapsed. All of them had thus sufficient warning to escape, but through carelessness or delay some of them failed to do so. One of the victims had escaped and was returning to rescue his tools when killed by the falling fire wall. Three other men retreated as far as the fire wall and supposed themselves in safety under its shelter when they were killed by its fall. H. L. Ellender, superintendent for the McLean Contracting Co., was killed while heroically endeavoring to rescue his men. Mr. Collin McLean, president of the company, was also seriously injured, but escaped by swimming. Mr. W. N. Edenson, superintendent for the Baltimore Bridge Co., who were the contractors for the steel superstructure, went down with the wreck, and after being seriously injured was obliged to swim a long distance through the wreckage before he could escape.

The shore-end of the pier was comparatively uninjured, but about two-thirds of the superstructure at the outer end was carried about 25 ft. transversely and sunk to the bottom in an upright position, with the second floor partly submerged. Except where it joins the uninjured portion of the pier the super-structure did not collapse and remained practically intact, as shown by the accompanying photograph, with the pent houses uninjured and only a single pane of glass broken in all of the sky-lights. The sudden immersion of such a great volume of material caused an enormous displacement of water and produced a powerful wave which was reported to have been about 6 ft. high on the opposite side of the harbor, one mile distant, and strong enough to tear many large boats from their moorings and expose them to serious danger, also threatening a number of workmen at the docks with drowning.

Immediately after the accident the work of removing the wreckage was commenced by the piledrivers employed on the work and since then a contract for removing the debris has been awarded to the Baltimore Bridge Co., which will doubtless be compelled to dynamite it, as the columns are so strongly bolted to the concrete foundation that they cannot de detached by divers. The preliminary estimate of the cost of removing the wreck is about $50,000.

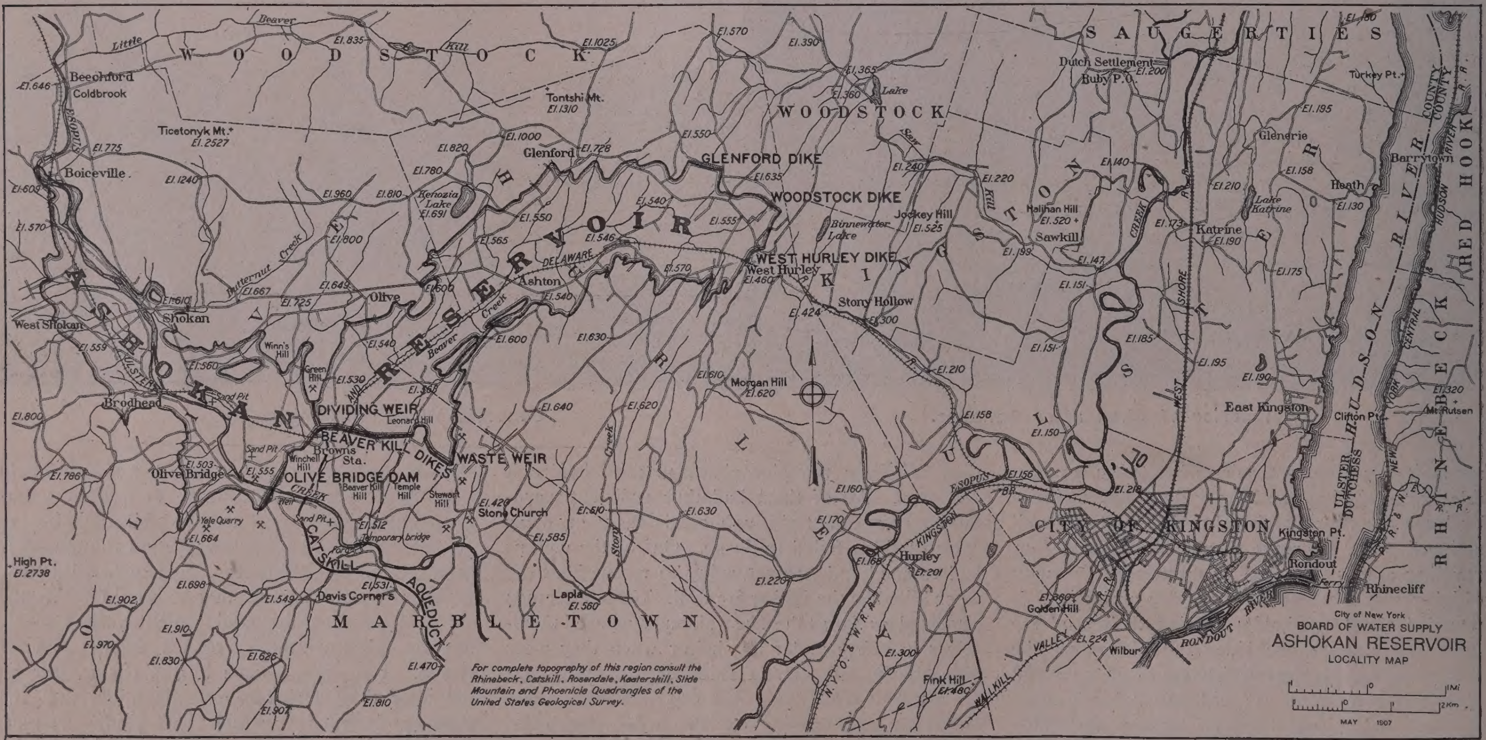
Mr. J. E. Greiner, assistant chief engineer of the Baltimore & Ohio R. R. Co., is quoted in the Baltimore "Sun" as saying that on April 20th "the engineers felt the pier moving. The concrete base began to crack and the engineers immediately began to remedy the defects. We found that the piles were tilting, and our efforts were bent to keep them solid. At least 6,000 cu. yd. of sand were deposited around the piles and we did everything that engineering skill could suggest to overcome the fault. It was the washing away of the mud that caused the piles to swerve and finally break away from the masonry, leaving the superstructure unsupported. We poured in sand hoping that it would serve the same purpose as the mud which washed away, but the piles continued to tilt further out of plumb. I do not believe it was overweight on the piles that caused the accident, but that the slipping away of the mud was wholly responsible. The piles did not sink in the least, because the clay supporting them was as hard as rock. The accident was the result of an unfortunate condition on the bottom which nobody could control."

The Duplication of a Church and parochial school was the condition of acquisition of a large property on Ninth Ave., in New York City, by the Pennsylvania R. R., for its terminal works. The property, which was desired for track connections, extends from 31st to 32d Sts., on Ninth Ave., and instead of obtaining it by condemnation proceedings, an agreement was reached with the church authorities to replace the buildings in exact duplication of every detail on a new site two blocks to the north. The design and interior decorations of all the new buildings, which have just been completed, corresponds exactly with those of the older buildings and the expensive stained glass windows were removed without change to the new buildings.

The Main Dams of the Ashokan Reservoir.

Designs for the main dams for the great Ashokan reservoir of the new Catskill water system for New York City are nearly completed, and the Board of Water Supply will soon be ready to advertise the contract for bids. This chain of masonry and earth dams will aggregate nearly 3 miles in length. While detailed estimates have not been completed, the total cost is expected to approximate, roughly, 10 to 12 millions of dollars. The locations of the dams have been determined, and may be visited by parties who think of bidding for the work. It is expected that active construction can begin during the summer.

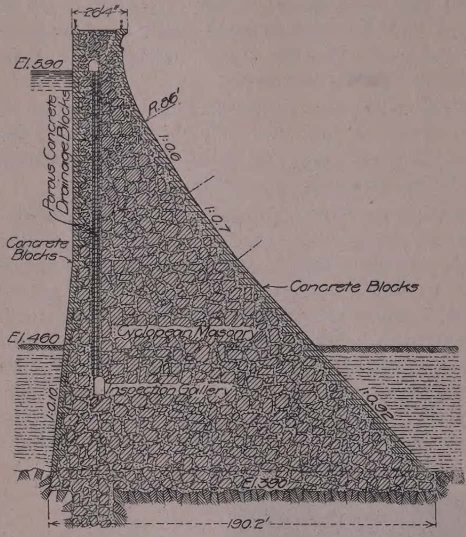
General descriptions of the great system of gravity water works by which New York City is planning to obtain from the Catskill Mountains an additional supply of over 500 millions of gallons of water daily, have been previously published. The first large contract, covering nearly 11 miles of the Catskill aqueduct in the vicinity of Peekskill, has been awarded to the Thomas McNally Co., of Pittsburg, and active preparations for construction are being made. The Ashokan reservoir, which will be the principal impounding basin in the Catskill Mountains, is in the drainage area of the Esopus Creek, northwest of Kingston. This reservoir will be about 12 miles long, with a maximum width of 2 miles, and will be divided into two nearly equal basins, one in the valley of the Esopus Creek, and the other in the valley of the Beaverkill, a tributary of the Esopus. The waters will be impounded by a large masonry and earth dam across the gorge of the Esopus, a series of earth dikes closing the valley of the Beaverkill and adjacent depressions in the rim of the reservoir, a dividing weir between the two basins, and an overflow weir from the eastern basin. An accompanying map shows the locations of these dams. The photograph shows the gorge of the Esopus at the Olive Bridge dam site.



For complete topography of this region consult the Rhinebeck, Catskill, Rosendale, Kaatershill, Slide Mountain and Phoenicia Quadrangles of the United States Geological Survey.

Map Showing the Site of the Ashokan Reservoir, Dam and Dikes of the New Water-Works for New York.

The principal dam, that across the Esopus, will be known as the Olive Bridge dam, and the chain of dikes to the east have been collectively designated as the Beaverkill dikes, and distinguished individually as the West dike, Middle dike, and East dike. Olive Bridge dam will have a length of about 5,000 ft. on top, and a maximum height in the river gorge of, approximately, 220 ft. The central part will be of masonry, with a cross section substantially the same as that of the Wachusett dam, for the Boston Metropolitan Water Works, at Clinton, Mass. The earth dams will have very liberal sections, and will, besides, have substantial masonry core walls. Abundance of good bluestone is available for the masonry, which will be of cyclopean rubble and concrete, and excellent earthy materials are available for building tight embankments. Sand, also, is found not far from the Olive Bridge dam site. The Ulster & Delaware R. R. crosses the line of the dams, and Brown's Station is near the center of the length of the chain of dams. Olive Bridge dam site is about 1½ miles, by road, from this railroad station.



Section of Main Dam.

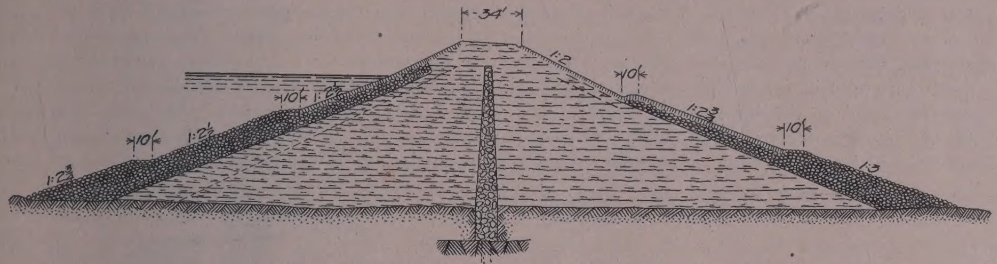
Esopus Creek has a drainage area of 259 square miles above Olive Bridge dam site. The dry weather flow of the stream is often but little in excess of 100 cu. ft. per second, a common range for such periods being from 100 to 300 cu. ft. per second. The creek, however, rises rapidly with heavy rainfalls and floods of 2,000 to 6,000 cu. ft. per second occur several times during the year. The brief records available show several floods as great as 12,000 to 15,000 cu. ft. per second, and the maximum of which there is any tradition is estimated to have reached about 38,000 cu. ft. per second. At the dam site, the stream flows in a rock gorge about 40 ft. deep and 200 ft. wide. The watershed of the Beaverkill is but 17 square miles. Hence, the quantity of water to be handled in this stream, during construction, is relatively small.

Water will be drawn from both basins through a great central gatehouse located at the junction of the dividing weir with the West dike. This gatehouse will have a capacity for handling water at the rate of 1,200 million gallons daily, so as to provide for a possible second aqueduct in the future, as well as supplying the aqueduct now under construction. To lead the water to this gatehouse so as to draw the two basins of the reservoir to low levels, two large channels will be required—one in each basin, excavated partly in rock, with a maximum depth of about 40 ft. A reinforced concrete arched bridge will cross the reservoir on the dividing weir, and there will be public highways on the tops of the dams. The magnitude of the proposed dams challenges attention. Approximately, 1,000,000 cu. yds. of masonry of all kinds will be required, and there will be nearly 6,000,000 cu. yds. of embankments. Another notable element of the work is the urgency for rapid construction, as the city is in great need of more water. Additional information can be obtained at the main offices of the Board of Water Supply, 299 Broadway, New York City, from Chief Engineer J. Waldo Smith, or Alfred D. Flinn, engineer of Headquarters Department. Mr. Carleton E. Davis is engineer of the Reservoir Department and has an office at Brown's Station. Appointments can be made for visiting the sites of the dams, and intending bidders would do well to become thoroughly informed concerning the field conditions, at an early date.

Licenses for two-sevenths of the architects practicing in Illinois had been issued up to Dec. 1, 1906, by the State Board of Examiners, after ten years' endeavor to license all.

The Greenville Terminal of the Pennsylvania R. R.

The Greenville Terminal of the Pennsylvania R. R. is located on a narrow strip of land south of Jersey City between New York and Newark bays. It is used exclusively for freight service, the yard being designed to separate and deliver shipments for export, and interchange traffic with New York and with the railroads running farther east. The terminal is part of the general improvement which the Pennsylvania R. R. is making in and around New York, and the design shows the same broad provisions for the future which characterize all the rest of the work. At the present time the terminal is only a little more than half completed.



Typical Dike Section, Ashokan Reservoir.

Site of the Main Dam of the Ashokan Reservoir.

The freight traffic concentrating on New York Bay presents characteristics which require a much different design than that of the average inland freight terminal. While in the latter the freight is forwarded by trains made up similar to those on which it reached the yard, here much of it is intended for export and the remainder for transshipment to lighters or for delivery by car ferries at various points on the bay. Moreover, the movements in the opposite directions have few characteristics in common, and require quite different methods for economical handling. The eastward movement, which is the heavier, consists entirely of loaded cars, while a large proportion of the total westward movement consists of empties. The west-bound freight in addition requires fewer classifications than the east bound, and is in consequence easier to handle.

The terminal is provided with the usual classification tracks for movements in the two directions, but there is strictly speaking only one receiving yard and one departure yard. The eastward departure yard is replaced by the transfer bridges and the lighterage pier, and the westward receiving yard is dispensed with and the cars are run directly from the ferries and the lighterage pier to the classification tracks. This results in a much shorter yard than would generally be required for the volume of traffic handled, the total length from the entrance to the bulkhead where the transfer bridges are located being about 10,900 ft. The width of the yard through the tracks now built and proposed is about 1,600 ft., and the maximum width of the property available for trackage about 2,700 ft.

The freight destined for the terminal leaves the main line at Waverly, N. J., 4 miles west of Harrison, and crosses Newark Bay parallel with the Lehigh Valley R. R. on a trestle 5,300 ft. long. The yard begins in Newark Bay near the end of this trestle and stretches in a southeasterly direction across the neck of land, and 5,300 ft. into New York Bay, the ultimate pier head line extending 4,400 ft. farther. Between the two main tracks near the entrance to the yard are located the caboose tracks, so arranged that the east-bound trains drop their cabooses into them by a trailing switch and the west-bound trains receive their cabins from the opposite end of the same tracks, by a switch similarly arranged. The east-bound receiving yard now consists of five tracks with a capacity of 75 cars each, but it will later be replaced by a 21-track yard, with a capacity of 65 cars each, the present tracks being then utilized as a west-bound departure yard. From the receiving yard direct access is had to the mechanical plant which is located south of the tracks, between the right of way of the Central R. R. of N. J. and the Morris Canal. Its present position and size are temporary, and on the completion of the terminal the plant will be transferred to the north of the yard and east of the hump. The present installation consists of an eleven-stall roundhouse, a coal chute, water tanks, and inspection and ash pits.

About 500 ft. west of the hump a series of crossovers is placed which allows access from any of the receiving tracks to any of the three distinct yards. Double tracks lead directly forward over the hump to the east-bound yards, a second pair of tracks runs to the north of the hump over a low-grade track to west-bound yard A and a single low-grade track south of the hump leads to west-bound yard B. The apex of the hump is located 100 ft. east of the Morris Canal. From this point to the farthest end of the east-bound classification tracks is 4,200 ft., but the grades have been so designed that no difficulty is experienced in sending cars the entire distance. The arrangement of these tracks is different from the usual design. There are nine ladders feeding 84 tracks, with an average capacity of 25 cars each. The great number of tracks and their small capacity is due to the peculiar function of the east-bound yard. The car floats have a nominal capacity of 22 cars, corresponding closely to the capacity of the classification tracks, and the short tracks, moreover, dispense with the tail switching which is necessary with long tracks when a few cars are needed out of a long string. The number of tracks is demanded by the great number of classifications, averaging 39 per day for the year 1906, and by the necessity of storing many short trains of shipments awaiting export. Yards A, B, C and D serve the transfer bridges, while E, F, north H and south H, handle freight for the lighterage pier or open dock, as it is sometimes called. The ladders are served by tracks which do not interfere with each other, and thoroughfare tracks are provided for easy access to all parts of the yard. The exits from the different yards are kept separate, so that a number of engines can work simultaneously without interference.

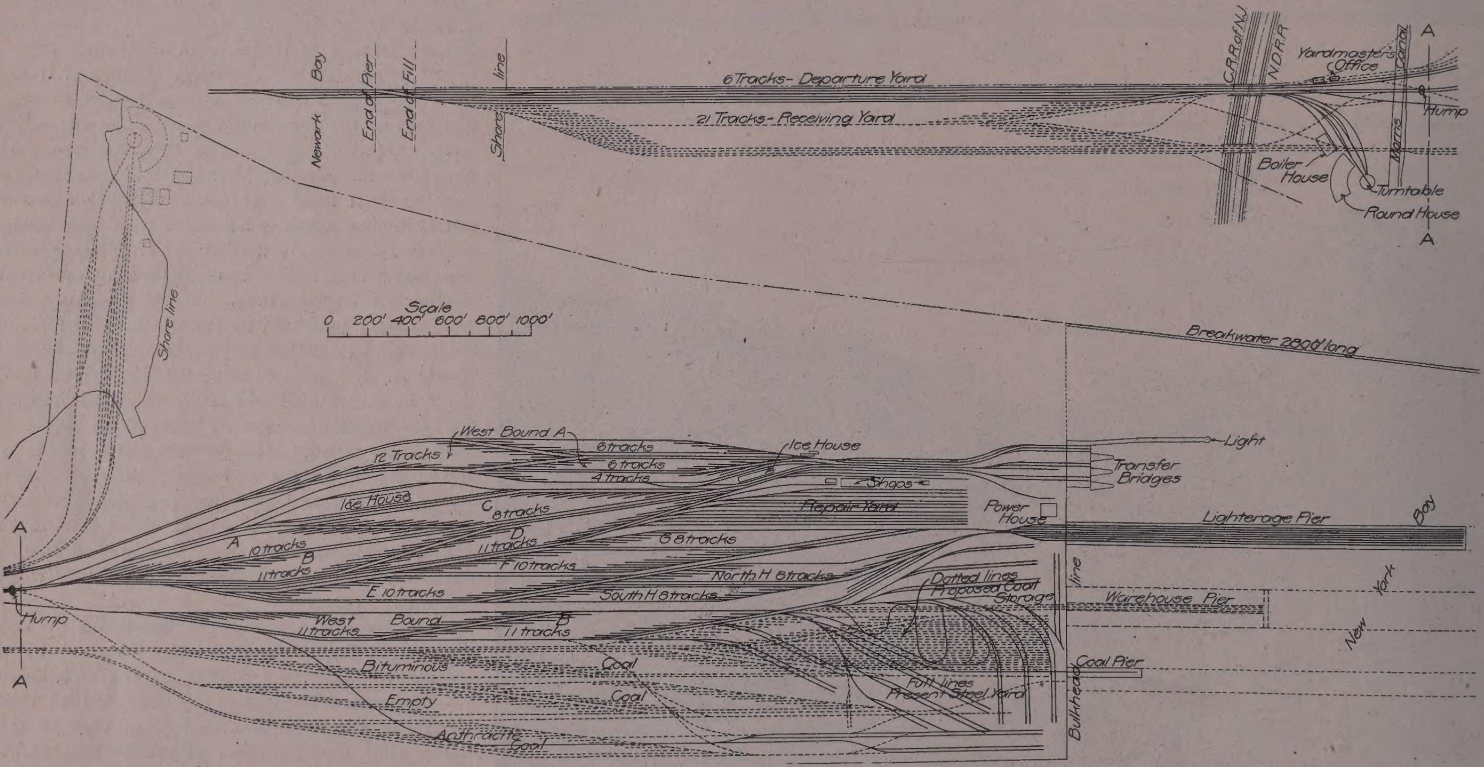
The cars are pushed over the hump by two engines, and the movement is governed by a semaphore under the control of the switchman at the hump. Ten riders are required to take charge of the cars, and they walk back to the hump after guiding them to the proper tracks. An interlocking system controls the entrance to the different ladders, but the switches on the latter are operated by hand. For this reason and also to provide a safe passageway to riders and other employees going through the yards, the distance between centers of a ladder track or a thoroughfare and the adjacent track in the next year is 17 ft. Poling cars are provided and are frequently found useful.

The car repair yard lies east of the east-bound yard and contains 11 tracks spaced either 16 or 20 ft. on centers. Where 20-ft. centers are used narrow gauge tracks are laid between the lines of cars, and provided with spurs leading to the wood and machine shops. These latter are located north of the repair yard, while the power house is directly east, close to the bulkhead which marks the end of the yard proper. It contains a 500-kw. Curtis turbine, which supplies the power for operating the various motors on the bridges and cranes, and the current for lighting the yard at night.

The west-bound yards, the A yard north of the east-bound tracks, and the B yard south of them, are at a lower elevation than the east-bound yard. West-bound yard A receives freight from the transfer bridges, and has five ladders serving 28 tracks of an average capacity of 25 cars, while west-bound yard B handles open dock freight and has two ladders leading to 22 tracks. The provisions regarding thoroughfare tracks and centers above described for the east-bound yard apply to these yards. Southeast of the yards described is a steel yard with large spaces between tracks to allow for the unloading and storing of structural steel. The material is handled by locomotive cranes.

The future extension of the trackage will be south of west-bound yard B, occupying what is now vacant land and the area given up to the steel yard. These proposed tracks will be used for coal traffic, and will be divided into three yards consisting of one or more ladders each, one for east-bound bituminous coal, one for east-bound anthracite and one for west-bound empty coal cars.

The starting grade on the hump is 2.5 per cent. and with the traffic consisting solely of loaded cars has proven entirely satisfactory. There are but 50 ft. of the maximum grade, succeeded by a 1 per cent. grade which continues through the yard to the entrance to G yard, beyond which it is 0.6 per cent. The yard is lighted at night with arc lamps distributed along the ladders, on the lighterage pier and at the transfer bridges, so that work goes on without interruption. Water mains are laid throughout the length of the terminal and there are fire hydrants at close intervals. Telephone and telegraph lines connect both ends of the yard with each other and with the public systems.



The Greenville Terminal of the Pennsylvania Railroad.

The transfer of cars to the floats is effected by three independent transfer bridges, each carrying two tracks. They consist of a bridge 80 ft. long, having three Howe trusses, and an apron 30 ft. long. The landward end of the bridge rests on a rocker, and its other end is hinged to the apron. At this point the bridge is supported from above by heavy links ending in machine screws 7 in. in diameter, which are raised and lowered through mechanism on the gallows frame spanning the tracks. The outer end of the apron is likewise suspended from the gallows frame, but steel cables are used instead of links. The height through which the apron can be raised approximates the distance between the level of the heaviest loaded float at low-tide and the level of an unloaded float at high tide. Each bridge with its apron is controlled by switches housed in a gallery overlooking it. Electric motors are used, and can lower the end of the apron or the bridge independently. The floats, which have three tracks and a capacity of 22 box cars, are made fast by lines thrown over two electrically operated drums at the ends of the racks, by two hauling-in gears, also electrically operated, located on the dock beside the end of the apron, and by two hand-operated mooring gears on the apron itself. These elaborate precautions make it practically impossible for the float to get out of position when once secured. All the motors except those on the racks are controlled from the operating gallery. Two heavy bars on the apron engage pockets on the float and prevent lateral movement, in addition to causing the apron and float to rise and fall together. When a float is brought in for loading or unloading the apron is raised to the level of the floor of the float, the latter is secured, and weights of 40,000 lb. are raised by the motors, and connected with the cables supporting the apron through gears. During the loading and unloading process these weights, together with the buoyancy of the water, serve to regulate the rise and fall of apron and float. The bridge, on the other hand, must be raised or lowered by the operator in order to keep it in the same inclined line with the apron. Two tracks on the float can be loaded at the same time, the bridges being designed to carry the weight of two locomotives, and the motors being of sufficient power to raise the bridge and apron when fully loaded. The floats are received loaded, and as soon as the cars are hauled off, are re-loaded with a consignment for the opposite direction.

The lighterage pier is 120 ft. wide and 2,000 ft. long. On it are eight tracks served by three 10-ton traveling cranes, two spanning the four north tracks, and one the four south ones. They are electrically operated, the current being taken from wires carried on poles down the center of the pier. Shipments are handled directly from the cars to lighters, which carry the freight to docks in New York and in different parts of the bay, and to the ocean-going vessels.

Extending into the bay is a channel with a minimum depth of 18 ft. and a width of 800 ft. reaching to the 18-ft. contour in the bay. The length of the channel is 6,400 ft. Future extensions provided for are the lengthening of the lighterage pier to 4,400 ft., the building of a warehouse pier 200 ft. wide and 4,400 ft. long and of a coal pier 100 ft. wide and of the same length. A coal dock 350 ft. long is now in use. Additional pier frontage is obtainable by the construction of channels on both sides of the yard. The frontage when completed will be 7.8 miles. A breakwater 2,000 ft. long and about 800 ft. north of the open dock affords harbor shelter for the vessels and floats.

The construction of the terminal was begun in March, 1900, and the present trackage, transfer bridges and piers were completed and put in operation in October, 1904. About 14,000,000 cu. yd. of material were required to grade the existing yards, and about 8,000,000 cu. yd. additional will be required to complete the work. Of the latter quantity much has already been placed and the work is now being carried on. Some of the material used in the original fill was dredged from the bay in constructing the channel. The material now being used is excavated from the Pennsylvania terminal site at 33d St., Manhattan, and consists of stones varying in weight from a few pounds to 3 tons. The scows are brought up two channels 150 ft. wide north of the yard, one being 3,000 ft. long, the other 4,000 ft. long. The scows are unloaded by five self-propelled land derricks on tracks on the banks of the channels, and three floating derricks. The material is put into scale boxes, which are swung over and emptied into 6-yd. standard gauge dump cars. In addition to these derricks a permanent unloading plant has been established in the south channel. A 2½-yd. Hayward orange-peel bucket picks the rock from the scows and loads it into the dump cars. When the larger pieces have been disposed of, the scows are hauled beyond the orange-peel by passing a line over an extra spool on the hoisting engine, and the small pieces shoveled into scale boxes which are operated by a stationary derrick. The capacity of the unloading devices is 5,000 cu. yd. in 24 hours. The work requires the services of 40 scows, 6 tugboats, 150 dump cars, and 5 dinky locomotives.

The stone is dumped outside the track toward the bay and as soon as a width sufficient for a track has been deposited the track is shifted to the new fill.

The present trackage capacity of the terminal is 5,000 cars, and the final capacity will be 7,560 cars divided as follows: Receiving and departure yard, 1,200 cars; east-bound, 4,070; west-bound, 2,290. Fifty-one miles of track are now laid, and when finished the total will be 91.3 miles. The terminal extends 5,300 ft. into New York Bay, and the distance from the shore line to the end of the channel at the 18-ft. contour in the bay is 11,700 ft. The average monthly movement is about 35,000 cars, the daily average about 1,100. Last year the number of classifications daily was 39, the number of cuts per day per 100 cars being 75. Twenty-two yard crews are employed, and 127 additional employees.

The present contractor, whose plant has been described and who also built the open dock and the transfer slip, is Henry Steers, Inc., New York. Other contractors who have shared in the work are: Thos. Potter, Jersey City; Hughes Bros. & Bangs, New York; H. S. Kerbaugh Co., Inc., Philadelphia, all of whom did part of the filling; P. Sanford Ross, Inc., Jersey City, dredging and filling; B. M. & J. T. Shanley Co., Jersey City, abutments, ballasting and track laying; and F. M. Stillman Co., steelwork.

The Construction and Maintenance of British Permanent Way.

The general attention now being given to track construction by American railway engineers lends timeliness to a paper that has just appeared in "Proceedings" of the Institution of Civil Engineers on British permanent way. The author, Mr. A. J. Grinling, summarizes in this article the best practice in Great Britain, and his statements enable the American reader to note readily the different methods in the two countries. He assumes that the necessary earthwork has been completed, and the banks and cuttings finished to the proper width at formation-level, depending, of course, on the number of lines of way to be constructed. It is important that the formation should be 2 in. higher in the center than at the sides, to allow of efficient drainage; and in cuts provision must be made, either by means of open ditches, where there is sufficient width, or by pipes of sufficiently large section, for carrying off any water they are likely to collect.

The bottom ballast is spread directly over the formation and constitutes the foundation for the permanent way. It should consist of hard, rough stone pitching, where this is available, not more than 9 in. in width on any face, laid on edge, and hand-packed as closely as possible. Where it is difficult to obtain stone, broken brick or slag forms an efficient substitute. In soft clay cuts, a layer of clinker or coarse gravel is sometimes spread over the formation to prevent the large stone bottom-ballast from squeezing into the clay, and in a wet cut this aids the drying up of the formation. It is also an excellent plan to spread 2 or 3 in. thickness of good ashes immediately on the top of the bottom ballast, Mr. Grinling holds, as this helps to keep the road dry. The total depth of the bottom ballast is usually about 12 inches.

A large variety of materials may be used for the top ballast, and the material adopted is usually that which can be most readily and economically obtained. The points to be aimed at are an easy-running road, good drainage, and a material in which the ties can be properly packed; absence of dust is also an important matter, in respect of both the life of the rolling-stock and the comfort of the passengers, and it is desirable that the material adopted should be one in which weeds will not easily grow.

The principal materials used for top ballast are granite chippings, slag, screened and unscreened gravel, hard well-burnt ashes, burnt clay, and broken stone.

Screened granite chippings form an excellent material for top ballast, as the ties can be evenly packed, good drainage is obtained, there is hardly any dust, and weeds will not grow in it; but except in the case of a railway running through the neighborhood of granite quarries the cost is against its extensive adoption.

Slag is now extensively used for ballasting, and presents many advantages, but there is considerable difference of opinion as to how small it should be broken. A usual specification is that it must pass freely through a 2-in. ring. If it is too large, the ties, instead of being supported over their entire area, tend to rest on a few large lumps; and it is also difficult to pick up slack joints. Many inspectors say that a road packed with large slag tends to get out of line, as the sharp edges form a kind of rocker-bearing for the sleepers to slide on.

Gravel, both screened and unscreened, is extensively used for top ballast. There should be sufficient sand present to render it compact, but not enough to interfere with the efficient drainage of the road.

Ashes are frequently used for lines in the neighborhood of collieries. They form a very elastic road-bed and afford excellent drainage, but they are scarcely heavy enough to steady a road for heavy express traffic. Care must be taken that ashes are not placed in contact with steel-work, such as the flooring of bridges, on account of the sulphur which they contain. The same rule applies to slag.

Where economy has to be studied and nothing more suitable can be obtained, burnt clay is frequently used for ballasting, but great care must be taken that it is sufficiently burnt, otherwise it will tend to consolidate into hard lumps under the influence of the weather. In the construction of a new line it is not true economy to cut down the estimate for ballast, as the outlay on a sufficient supply will be amply repaid in the subsequent maintenance of the line.

Broken stone, like slag, if broken small enough and free from dust, forms a good material for top ballast, but stone that weathers rapidly should be avoided for ballasting.

Baltic red-wood is the timber most generally used for ties in Great Britain, although some companies use memel, Scotch fir, and red pine. Foreign hard woods, such as Australian karri-wood, are now being experimented with. Beech also has been recommended as a suitable timber, and has been used with good results on several continental railways. Ties are usually 8 ft. 10 in. in length, 10 in. in width and 5 in. in depth. They are creosoted.

Hitherto the rails used by different companies have been of slightly different weights and sections, but in future renewals these differences will probably be abolished by the introduction of British Standard sections. The following are general dimensions and weights of British Standard rails:

No. of Section.	Height of Rail.	Width of Head.	Weight of Rail.
85	$5^{15}/_{32}$ in.	$2^{14}/_{16}$ in.	85 lb.
95	$5^{23}/_{32}$ in.	2¾ in.	95 lb.
100	$5^{29}/_{32}$ in.	2¾ in.	100 lb.

On all English railways using bull-headed and double-headed rails, the rails are supported in cast-iron chairs, fastened to transverse ties by various kinds of fastenings. The iron must be of good quality, so that in a transverse bending-test a bar 1 in. in width and 2 in. in depth, placed on bearings 3 ft. apart, shall bear a load of 30 cwts. in the center without breaking, and show a deflection of at least ¼ in. In designing a chair for heavy traffic it is essential to give it a large bearing-area, so as to distribute the weight as much as possible over the ties; otherwise the chairs will tend to sink into the tie and damage it. The bearing area and the weight of the chair vary considerably on different railways; the latter should be not less than 40 lb. for heavy traffic, according to Mr. Grinling. The Great Northern Ry., in recent renewals of permanent way, has introduced a new form of chair on either side of the rail-point, in order to strengthen it. These are known as inter-joint chairs. They are similar to the ordinary chairs so far as the jaw is concerned, and hold the rail in exactly the same way; but the rail-seat is cast with a projection, on which the rail rests, thus considerably reducing the unsupported length at the joint. This chair is designed to reduce the risk of fractured fish-plates, but at the same time it has the advantage of not interfering with the elasticity of the road, as the ends of the rails are left free. On the main line a 12x6-in. tie is placed under these chairs.

The fastenings which are used to connect the chairs to the ties are of various kinds, comprising solid oak treenails, spikes, coach-screws, and fang-bolts. The Board of Trade requirement is that at least one fastening of each chair must be an iron spike or bolt. A very usual method of securing a chair to the tie is by means of two wrought-iron spikes and two compressed oak treenails, placed diagonally. Spikes are usually about 6 in. in length and ⅝ to ⅞ in. in diameter. The spike is considered to be strong enough to resist any shearing-stress that may occur, and the treenail, which is not considered to be so strong, is supposed to swell under the influence of the weather and to fill up the hole completely, thus tending to keep the chair perfectly tight and prevent it having any lateral motion.

The form of joint almost universally adopted in Great Britain is the suspended type, the rails being connected by two fish-plates bolted together through the rails by four fish-bolts. Fish-plates are now made much shorter than formerly, in order to bring the chairs and ties at either side of the joint as near to one another as possible, 18 in. being the usual length. The bolt-holes are either square, circular, oval, or pear-shaped. The corresponding holes in the ends of the rails are larger, to allow for expansion and contraction, and it is usual to specify that they must be drilled, while those in the fish-plates are frequently punched.

Fish-bolts are usually cup-headed, with square or pear-shaped shoulders to prevent the bolt turning round while the nut is being screwed up. The nut of the fish-bolt may be either square or hexagonal, and lock-nuts are now generally used.

Double-headed and bull-headed rails are held in position by means of wooden wedges or keys. Both hard and soft woods have been used for this purpose. Soft-wood keys are usually compressed in order to drive out all moisture before they are placed in the road, the idea being that when driven into position the key will absorb moisture from the atmosphere and expand; but in spite of this treatment wooden keys are liable to shrink and drop out during a spell of very dry weather. Oak and teak are both suitable woods for keys.

Construction.—In the case of a new line of considerable length, the materials are sent down in train-loads and unloaded at suitable spots, and are thence taken in trolleys to the exact place where they are to be laid. In relaying or widening an existing line, the materials are loaded up at a district depot, and, where the distance is not too great, the gang which loads the materials generally travels on the train, and unloads them at the other end. In relaying a line, the materials are unloaded between the times of the ordinary trains, by the side of the old track, where they are subsequently to be laid. Ties and rails are usually loaded in specially-constructed wagons.

Assuming that the bottom ballast has been already laid down, the first operation will be to lay the ties approximately in position on it. In modern practice the chairs are attached to the ties before the latter are sent out. If the ties are to be placed in the ground with their sawn side downwards, they are first passed under two revolving cutters in order to ensure the chair-seats being perfectly level; they are then passed under another machine by which revolving augers are brought down on the tie, and the holes for the fastenings are bored out. This ensures a uniform gauge. The chairs are next placed in position on the tie, and driven or screwed home, depending on the nature of the fastening; this is sometimes done under pressure, to make the fastenings take a firm grip. Attaching the chairs to the ties before the latter are sent out saves a great deal of time on the ground. The old-fashioned method was to attach one line of chairs, and spike the other line to gauge after the rails had been placed in position. Most companies place their ties in the ground with their sawn side downwards, the advantage being that any damp tends to run off the ties, whereas if they are placed with the heart side upwards the damp has a tendency to penetrate, ring by ring, into the fibres of the wood, and so cause the ties to rot. Ties placed sawn side upwards look neater, and the chairs do not sink so readily into the heart-wood as they do into the sap.

The ties and chairs having been laid approximately in position, the rails are picked up with suitable rail-tongs and dropped into their places. The old-fashioned method of lifting without tongs requires more men per rail, and the risk of injury to the men is much greater, as they are more liable to let the rail drop. The spacing of ties varies with different companies, eleven or twelve ties to a 30-ft. rail being a usual arrangement. The joint-ties should be placed closer together than the others, and the space between the second and third tie from the joint is usually a little less than that between the others. The positions of the ties should be marked off on the rail by means of a divided rod, which serves as a template, a chalk mark being made on the rail at the center of each tie; the ties are laid at right-angles to the rail by means of a large square. In fishing two rails together, an expansion-piece is placed between the ends of the rails, and the latter are driven close up. The space left for expansion varies between ⅛ and ⅜ in. according to the length of the rail and the temperature at the time the rails are linked in. The two middle fish-bolts are screwed up first. Care should be taken that the rails are in line and level before tightening the bolts, otherwise the strain of bringing the rail into exact position will fall on the plates and bolts. The latter should be oiled before being used.

In fishing together rails which do not quite correspond in section, as in the case of relaying, where a new rail must be joined up to one that has become worn, or to a rail of lighter section, it is necessary, in order to get the joint perfectly level, to use junction fish-plates, one-half of the plate being deeper than the other to make up for the difference in the height of the two rails. In keying-up it is now considered best, in order to prevent creep, to drive the keys in the direction of the traffic, on a double line, and in the direction of the heavier traffic, if there is any difference, in the case of a single line. The effect of the passing of a train is then to tighten the keys, not to slacken them. In order that the joint-ties may be brought as near to one another as is permissible, consistent with easy packing, one of the keys at the joint will have to be driven in the reverse direction.

In tamping a road, the joint-ties should be tamped first. The main object to be aimed at is to have the tie resting evenly over the ballast, and not merely supported on a few large lumps. Tamping is best performed with a shovel; if a beater is used the ballast is almost sure to be harder in some parts than in others and this is against easy running. The joints having been accurately levelled, the next operation is to pick up and level the intermediate ties. After the road has had time to be consolidated, it is lifted still further by additional tamping until the rails are at the requisite finished level; 2 to 3 in. is quite sufficient for a single lift.

The ballast which is not actually packed but lies on and between the sleepers is termed "boxing" in Great Britain. On some lines the ballast is brought up flush with the top of the ties, thus leaving the surface of the latter exposed. Covering the ties with ballast to a depth of 1 to 2 in. tends to keep them at a more equal temperature, and also to prolong their life, as decay is no doubt accelerated by leaving the top surface exposed to the alternation of damp and heat. The ballast should extend about 18 in. beyond the ends of the ties, and from this point it should be trimmed down to formation-level.

Maintenance.—For purposes of maintenance the line is divided into lengths of about 2 miles, with three to six men to a length, depending on the nature of the length. In every gang there should be a ganger, and also a second man who is competent to take the ganger's place in his absence. It is usual to have a permanent-way inspector to every 15 to 30 miles, also depending on the nature of the line, the work of maintenance being much heavier on some sections than on others. To every ten gangs, say, there should be a small extra gang of five or six men, for strengthening the length-gangs for special work, such as lifting a considerable length of the road, watching the line in time of flood, repairing slips, etc. Each inspector should have a time-keeper to relieve him of all clerical work, and to assist him in the supervision of the men. Where it can be arranged, the regular men should be kept entirely to their own lengths, and not taken off, except in cases of great emergency; when it is necessary to relay or renew important points and crossings the help of the extra gang should be called in.

This extra gang is quite distinct from the small extra maintenance-gangs mentioned above. It should consist of 24 to 30 men, under the charge of a foreman, who should be thoroughly skilled in all permanent-way operations, and an assistant foreman and several men should be specially trained for such duties as keying, fishing rails and spacing ties. It is desirable that the extra gang should contain a nucleus of permanent men, and where the work of a division can be arranged this should constitute as large a portion of the gang as possible, as the extra trouble involved in arranging the order of the work is amply repaid both by the quality and the quantity of the work done; and such men will carry out the work with greater safety to themselves and to the public.

The following are the particulars of the daily routine of work of a maintenance gang. The ganger is responsible for his length of the line being kept in good order. He should walk over it twice a day, once early in the day and again in the afternoon; the second man may, however, frequently make the latter journey. Before leaving his men in the morning the ganger should start them on the work they are going to do. While making his tour of inspection he should carry with him a keying-hammer and a spanner, and examine the line for any defects, such as broken rails and chairs, slack keys and fish-bolts, broken and worn-out fastenings, rectifying small defects by driving in slack keys and screwing up loose bolts as he goes along. He should walk along on one side of the track, and return on the other.

Each gang should work along their length of the line in a systematic manner as far as possible. Their duties are: (1) Keeping the road truly in line, and at its proper level. This involves straightening the road, and packing the ties from time to time, as may be necessary. (2) Keeping all drains and culverts free from obstruction. (3) Cleaning and oiling switches and keeping the switch-rods and signal-wires clear of dirt and weeds, but leaving the actual repairs of any portion of the apparatus to the signal department. (4) Trimming the cesses and removing all weeds and rubbish from the line.

The ganger should pay great attention to any damp places that may occur on his length; it may be necessary, after heavy rain, to open up the road in order to get rid of any accumulation of water, and such places should be attended to with as little delay as possible. The ganger should bring to the notice of the inspector any defects, not only in the permanent way itself, but in the various structures on his length that he may notice in his daily inspection. The principal duty of a maintenance-gang consists in keeping the road in as good condition as possible; they should not, however, be encouraged to undertake heavier work than they can manage efficiently, but should apply for help from the small extra gang when necessary, as, for example, in lifting a considerable length of road, pulling back rails, and the like, for if they spend too much of their time in one place the rest of their length is liable to suffer.

The readjustment, or pulling back, of rails which have crept and so caused the joint to get out of square, comes under the head of maintenance, and in some cases it is a very troublesome matter to deal with. Rails always tend to creep or travel along the line of least resistance. The trouble arises from the lateral grip of the fish-plates being too tight, thus preventing each rail from traveling independently, and causing a creep to be transmitted from rail to rail. It is almost impossible to give any reason for the creep taking place in a particular direction, as what occurs at one place is almost certain to be contradicted at a simlar place elsewhere. Creep is supposed to be influenced by the temperature, the direction of the traffic, and the gradient; and also by the position of the fish-bolts in the holes, for if they are tight up against the rails at one end, and therefore have plenty of room to expand at the other end, this in itself might be sufficient to cause the rails to start creeping in that direction. It is probably not wise to go too far in measures for the prevention of creep, for fear of buckling the road, as the force of expansion is so great that if the rails are not left free to expand in the direction of their length they have no other alternative than to buckle laterally, and so throw the line out of gauge. Sometimes the right and left-hand rails travel in opposite directions, and even where both lines of rails creep in the same direction, one will almost invariably creep more than the other. Creep must not be allowed to go too far before being attended to, or it will be necessary to pull back the rails for a very considerable length.

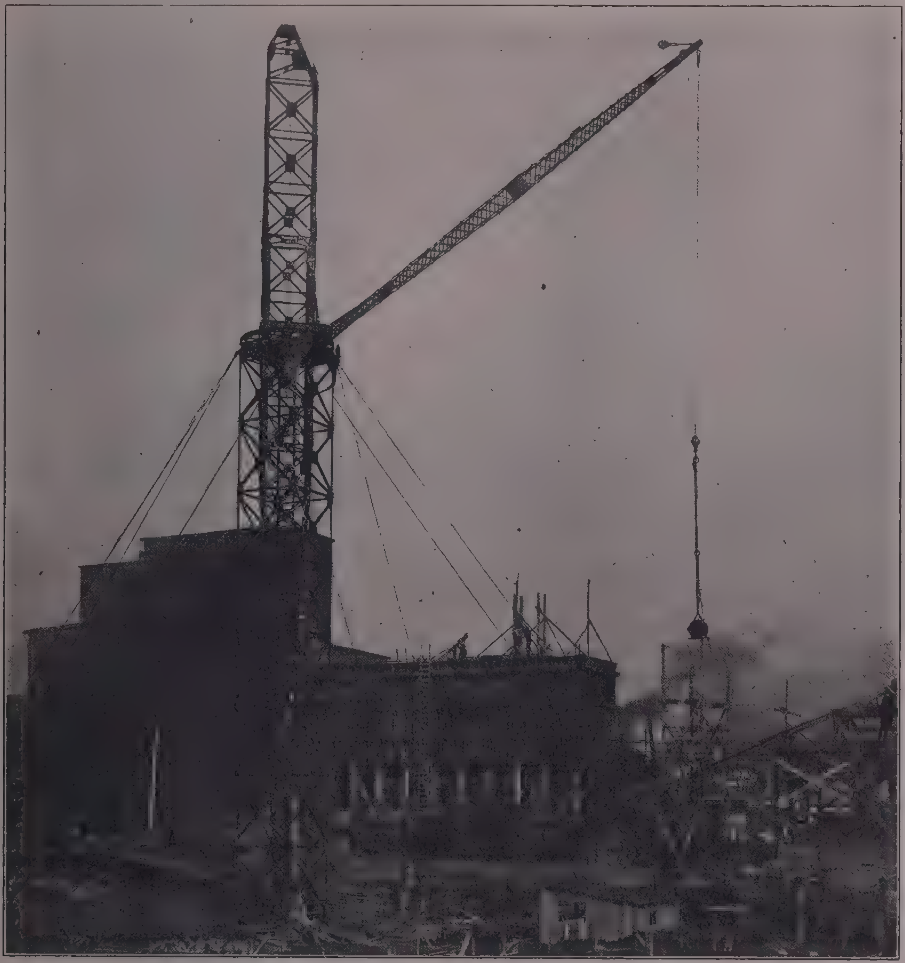
A Serious Cave-in occurred recently in the Copper Ridge tunnel of the Louisville & Nashville R. R., 17 miles north of Knoxville, as a result of a collision-wreck. A fire started which burned a locomotive, a caboose and several freight cars; this destroyed the wooden lining of the tunnel for a distance of 1,000 ft., and as a result the roof of the tunnel caved in for the greater part of this distance, closing the line for some time.

The Contractor's Plant Used in Constructing the Montgomery Ward Building, Chicago.

An eight-story reinforced-concrete building covering an area of over 3 acres is under construction in Chicago, at Chicago Ave. and the north branch of the Chicago River, for Montgomery Ward & Co. The site of the building is between the river and the two main line tracks of the Evanston division of the Chicago, Milwaukee & St. Paul Ry. A bend in the river occurs at the site and the railroad follows this bend, so the building is irregular in plan, being 150 ft. wide at one end, 750 ft. long and 270 ft. wide at the other end. The building will extend up to a concrete dock that is under construction along the harbor line on the river side. On the opposite side the outer wall of the building is parallel to and 30 ft. from the center of the adjacent main line railroad track for a length of about 420 ft. from the narrow end of the building, and then makes an angle of approximately 30 deg., corresponding to th[illegible]end in the river; the railroad curves at that [illegible] and beyond the curve the side of the bu[illegible]s parallel to the tracks again, abutting [illegible]w city street between it and the trac[illegible]

Solid rock lies a[illegible]over 100 ft. at the site and the [illegible]soil over it are of such charact[illegible]footings of the building are [illegible]. A basement with its floo[illegible] and 10 ft. below the str[illegible]t the grade of the railro[illegible]l under all of the bui[illegible] 85 ft. wide abo[illegible]e where four s[illegible]ilding slight-[illegible]The building w[illegible] and transse[illegible] introduced by the irregularity of the site, the bays having the same dimensions on all floors in order to simplify the form work and the construction.

The site was nearly all covered with old brick buildings of various sizes which were occupied by a brewery and by several small factories. After these buildings had been removed, the excavation for the basement was started with a Vulcan steam shovel having a 1½-yd. dipper. The excavated material was hauled from the shovel to the river in 3-yd. cars operated in trains with light locomotives on narrow-gauge tracks laid on the bottom of the excavation. The material was dumped at the river into scows in which it was towed out into Lake Michigan. The shovel worked against a face of 10 to 15 ft., the material encountered varying from river silt, muck and the footings of the old buildings at the surface to stiff clay at the basement floor level. The total excavation amounted to 58,000 cu. yd., the contract for this work being executed by James J. Lynch, of Chicago.


One of the Four 135-Ft. Steel Derricks.

The building requires a few more than 13,000 piles to carry its footings. These piles are from 40 to 55 ft. long and are generally driven their full length, bringing up on the harder strata of clay deeper down. The pile driving was started as soon as enough of the excavation had been made so the driving outfits could be placed. Three ordinary land driving outfits, with steam hammers, have been used for all of the work back from the river, and a floating outfit will be installed to drive the piles for the dock and those along the river side of the building. About 70 per cent. of the piles have been driven, the work being done by Walsh & Masterson, of Chicago. The clay at the site has so much tenacity and the piles are necessarily so close together that as the driving progresses the soil rises until in places it is 2 to 3 ft. above the bottom of the original excavation.

The general contract for the erection of the building was awarded to the George A. Fuller Co., of Chicago, on a cost-plus-a-percentage basis. The building is to be erected practically as a monolith, that is, the whole structure will be carried up a floor at a time, so no space will be afforded on any part of the site for storing materials. The space around the building is very limited and is so located that the greatest problem of the construction is therefore to supply materials to all parts of the work at the proper time and in the most economical manner. In a steel-frame building the steel work could be fabricated readily in such a way that it might be placed in position directly from the wagons or cars on which it would be delivered. On the other hand, with a concrete structure of this size, in which about 100,000 cu. yd. of concrete, 5,500 tons of reinforcing metal, over 4,000,000 ft. board measure of lumber, 5,000,000 brick, and so forth, are required, it is necessary to have a large amount of materials on hand to keep the concrete mixing plants in continuous service.

Along the river side there is, of course, no storage space available, and as the narrow end of the building faces on a busy street nothing can be placed in the latter. About half of a space, which in plan is approximately the quadrant of a circle with a 275-ft. radius, is unoccupied at the wide end of the site, but owing to its location could not be utilized for storing concrete materials, and at any rate is completely covered with storage piles of lumber for forms and by a planing mill which the contractor has installed for making forms. A switch track extends around the end of this space and provides temporary storage for seven cars, which will be required for lumber, steel and so forth. The only space available, therefore, for handling concrete materials is between the building and the main line tracks of the railroad. The two tracks of the latter carry a large volume of traffic, so they must be kept free at all times. At the same time, the narrow space between the tracks and the building is occupied by a switch track on which construction materials are delivered, so no storage space whatever is available at the ground level.

A large storage plant through which the concrete materials will be handled mechanically has been erected toward the narrow end of the building and over the switch track between the latter and the main line tracks. Owing to the very narrow space available and to the necessity of providing sufficient clearance for cars on the adjacent main track, this plant is confined to a width of 22 ft. The plant consists of a storage bin, having a capacity of 700 cu. yd., erected over the switch track so box cars on the latter can pass under it, and a Robins conveying belt system elevating the materials to this storage bin. The sand and gravel are obtained from pits on the Chicago, Milwaukee & St. Paul Ry. near Elgin, Ill., about 30 miles from the city, and are delivered for the most part in bottom-dump or side-dump gondola cars. A receiving hopper is built under the switch track at the plant and is long enough to permit two cars to be unloaded into it simultaneously. The bottom of this hopper is on a 45-deg. slope toward the building side of the plant. An 18-in. horizontal Robins belt conveyor, 65 ft. between end pulleys, extends along that side of the receiving hopper at the level of the bottom of the latter. The gravel and sand are fed separately on this belt through twelve gate openings in the side of the hopper. These openings are each controlled by a very simple paddle-shape gate which turns on a single bolt at the top of the blade of the paddle portion. These gates have been found quite effectual in delivering a uniform quantity of materials to the conveyor, which is one of the essential factors in the economical operation of a belt-conveyor system.

The horizontal belt conveyor travels 400 ft. per minute, its rated capacity being 4,000 cu. ft. of materials per hour. This conveyor delivers at one end to a second 18-in. Robins belt conveyor, 133 ft. between end pulleys, which runs up a 22-deg. incline on a trestle extending out from the end of the plant between the switch track and the building. The conveyor delivers at its upper end to a third 18-in. Robins belt conveyor, 117 ft. between end pulleys, which doubles back on a 22-deg. incline extending up over the end of the storage bins. This third conveyor passes over two fixed trippers and thence to an end delivery. Two gates are placed at each tripper and two at the end delivery so the materials can be discharged at any one of six points along the longitudinal axis of the bins. The fixed trippers enable one belt to be used and avoid the necessity of two short belts over the bins, as are usually employed, thus eliminating the separate drive that would be required for such belts. The two long inclined conveyors are driven from the same shaft by a 35-h-p. motor in a house at the upper end of the 133-ft. conveyor. The horizontal conveyor along the gates at the bottom of the bins is driven by the 133-ft. conveyor through a cross chain belt built by the Link Belt Chain Co. The motor driving the conveyors is controlled entirely by an attendant in a small house on the building side of the bins, this man also controlling the operation of a motor driving a concrete mixing plant in connection with the storage plant.

A 1½-yd. Ransome mixer is set in the 8-ft. space between the side of the building and the structure which carries the storage bin. This mixer is driven by a 35-h.-p. motor and is set so it delivers on a platform at the level of the basement floor of the building. A charging hopper with a capacity the same as that of the mixer is built in a floor over the latter. Gravel and sand are fed into this hopper from the storage bins by gravity. About two carloads of cement in bags are stored on the floor over the mixer, and cement is supplied to the latter by hand, two men being able to handle this work.

The long distances over which the concrete has to be moved from the mixing plant to place in the building require some means of quick and certain transportation. Isolated mixing plants throughout the building were not considered feasible owing to the difficulty of supplying them with materials and of taking the concrete from them. These difficulties would of course be greatly enhanced by the fact that to every 17.5x17.5-ft. floor bay of the building sixteen supports for the forms will be required. For the same reasons, it was considered that the usual form of barrow hoists could not be operated satisfactorily. The original plan was to mix the concrete at the storage plant that has already been installed, and at a second storage and mixing plant of the same arrangement and capacity which was to be located over the switch track and toward the wide end of the building. The operation of the existing storage plant has demonstrated, however, that this plant will probably have sufficient capacity to supply materials to the mixing plant built in connection with it and to a second mixing plant of the same capacity, so a second storage plant will probably not be erected.

Four large steel derricks set so as to command the greater part of the site will handle the concrete in buckets from the mixers to place in the building. One of these derricks has been in service for two months and has demonstrated the practicability of this method of transporting the concrete. This derrick consists of a steel tower, 10 ft. square and 85 ft. high, in which is operated a cantilever steel mast, 135 ft. long, that carries an 80-ft. steel boom just above the top of the tower. The derrick covers a circular area 170 ft. in diameter and can lift to 150 ft. above its base, which is 15 ft. above the roof line of the building. The tower is guyed at the top by eight ¾-in. cables, two at each corner, to anchorages buried under the basement floor level. The mast revolves on a pivot at its base and carries rollers at the level of the top of the tower which bear against a horizontal ring made of railroad rail that is carried by the tower. The boom, being entirely above the guys, can be turned through a complete circle without interfering with the guys.

The pivot on which the mast revolves is similar to those used for railroad turntables. A heavy cast-iron base resting on the footing for the derrick carries a hemispherical bronze casting; on this rests a steel cap of slightly larger radius, which is carried in the base of the mast. The bearing is thus steel on bronze and is designed so the pressure on it is always normal to the base, even when the derrick is tilted from the vertical by a heavy load.

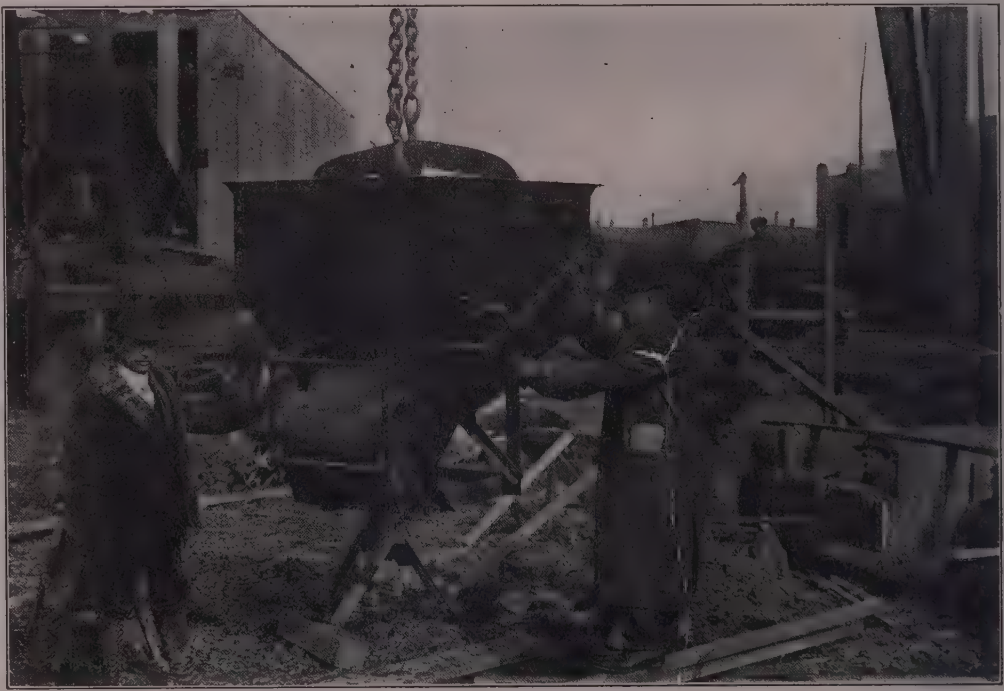
The mast is revolved by a bull-wheel at the top of the tower, the two cables necessary to turn this wheel being brought over sheave wheels at the base of the tower. The boom is operated by the usual topping and hoisting lines, both of which are brought down through the center of the mast and through a hole in the center of the bearing at the base of the latter to sheave wheels under the derrick.

A 25-h.-p. double-drum electrically-operated Thomas hoist, equipped with a derrick swinging spool and set at the level of the basement floor, operates the derrick. This hoist is run by an operator whose previous experience was with steam hoists only, and has given very satisfactory service.

The mast of the derrick was delivered to the site in four sections, which were spliced together on the ground. The assembled mast was then erected in place with a guyed wooden derrick having an 85-ft. mast. It was guyed in position by the cables used afterward to guy the tower, and the latter was erected around it; the guys were transferred to the top of the tower when it was completed. The derrick is placed so a single floor panel only will have to be omitted in the construction of the building, and the guy cables are arranged so they will pass through pipe sleeves in the floors without interfering with the construction of the floor girders at any point.

The original intention was to employ eight derricks of this size and type, but the adoption of a special type of dumping bucket for handling the concrete and of a system of portable Koppel narrow-gauge tracks for flat cars to carry these buckets from the mixer to the range of the derricks has eliminated the necessity for four of the derricks. The derrick that is now in service can reach the concrete mixer and also a large portion of the narrow end of building, so that for work on the foundations a system of tracks is not required for this derrick. A second derrick similarly situated at the second mixing plant will also be able to work over the foundations within its range without a system of tracks during work on the foundations. The third and fourth derricks will require tracks from the start, and the other two will require them after the lower part of the building has been erected. These tracks will extend along the basement floor from the mixing plants to the site of one of the elevator shafts or stair wells within the working radius of each derrick. The buckets will be delivered on the flat cars to these openings and then hoisted by the derricks to the floor on which work is in progress; the forms and the other materials will be handled in the same manner. As the derricks combine the hoisting and swinging motions in one machine, they avoid the delay usually occurring in building construction in the distribution [illegible] the concrete after the latter has been brou[illegible] to the desired level. As they can elevate a[illegible]stribute materials to the roof level all ne[illegible]f raising them as the construction prog[illegible]iminated.

One of the sp[illegible] that is used for handling the co[illegible]n in an accompanying illustrat[illegible] has a hopper bottom fitted wit[illegible]erated undercut gate of the[illegible]ed on coal chutes. The co[illegible]ay be discharged at any[illegible]ring the amount of open[illegible] forms have been fille[illegible]atisfactorily witho[illegible] out the excess[illegible] sults from a [illegible] dumped into [illegible]s


Special Concrete Dumping Bucket.

have also been used in placing concrete in comparatively thin layers while suspended from the derricks.

An angle-iron frame with four legs is built on the under side of each bucket, around the hopper bottom and gate of the latter, and the bucket stands on these four legs of the frame when it is not suspended from the derrick. In the construction of the portion of the building which is not within the range of any of the four derricks the buckets will be set on elevated platforms at the edge of the circles commanded by the derricks and the concrete will be hauled from them in wheelbarrows, this method having already been employed with good results on the foundations. The platforms are placed about 3 ft. above the level of the floor on which they stand, and wheelbarrows are filled one at a time from the buckets. These platforms are built large enough to hold two buckets, each of the latter having a capacity of 42 cu. ft., so concrete can be supplied fast enough to keep busy a large gang of men with wheelbarrows.

The efficiency of the system of portable narrow-gauge tracks and cars has been well demonstrated on this work in delivering sand and gravel from the elevated storage bins to a temporary concrete mixing plant. The latter is against the retaining wall on the railroad side of the building, at the level of the basement floor and 300 ft. from the storage bins. It embraces a 1-yd., motor-driven Smith mixer fed through a charging hopper having its top level with the platform built over the mixer, the platform being level with the grade of the railroad tracks along the building. A portable narrow-gauge Koppel track extends from the platform to the sand and gravel storage bin. The sand and gravel are fed into 1-yd. ball-bearing Koppel dump cars at the storage bin and are delivered on this track by hand, the materials being dumped from the cars directly into the charging hopper. With a man at the feeding gates at the storage bin and two men each pushing a car, as high as 130 cu. yd. of materials have been delivered from the storage bin to this temporary mixing plant. In fact, the sand and gravel are always supplied as fast as required at the latter.

The planing mill which the contractor has installed contains, in addition to a 24-in. motor-driven planer, two motor-driven rip saws, two motor-driven cut-off saws and a motor-driven band saw, boring machines, and so forth. The forms for the columns of the building are assembled complete in this mill. The two sides and the bottom of each girder form are built on templates in the planing mill, as the girders practically all have the same cross-section and length, and are assembled in place. A system of portable, narrow-gauge Koppel tracks extends from the lumber storage piles to the planing mill, and thence to those in the basement of the building. The lumber and forms will all be handled on cars on these tracks, and the latter being arranged so lumber that has to be sawed to length only is handled by one of the cut-off saws at the side of the mill and does not enter the latter.

The work is being carried on by the George A. Fuller Co., under the supervision of Mr. Edgar S. Belden, engineer and general superintendent for that company, who devised the derricks, concrete buckets, storage bins and so forth that have been described. The building was designed by Messrs. Richard SCHMIDT ~~Smith~~, Gardner & Martin, architects, of Chicago, who are also the engineers for the building.

THE GLASGOW HARBOR TUNNEL opened in 1895 will be closed at once by the company owning it, as it has never paid expenses. It has three tubes each 16 ft. in diameter reached by elevators in a shaft at each end.

Passenger Traffic in Greater New York.

There are few requirements of a technical nature connected with a large and growing city which are more closely related with the everyday work of its residents than that of good passenger transportation. The enormous losses of time which are incurred in going from one point to another, even with the best systems of transportation, make it highly desirable for all possible assistance consistent with sound public policy to be given to those who have charge of such service. In the case of Greater New York the conditions are such that extensions of the urban railway facilities must be carried on all the time or congestion will result during the hours of heavy travel, a condition which has several serious results to the city itself, such as sending thousands of people into New Jersey to live who ought to be taxpayers in New York. The enormous extent of the passenger traffic is well shown by figures given by Mr. George S. Rice, chief engineer of the New York Rapid Transit Railroad Commission, in his report for 1906, which will shortly be published.

Considering all the boroughs grouped into one great population center, it appears that during the four years ending June 30, 1905, the total number of paid passengers traveling on all street railways—surface, elevated and subway roads—increased practically in a straight line. During 1906, however, there was a sudden marked increase in the traffic. While the average increment for the four preceding years was only about 63,000,000 per year, during 1906 it amounted to nearly 110,000,000. No census of the population of the Greater City was made in 1906. It is therefore impossible to determine whether this large additional number of riders is due to a corresponding increase in the population, or to an increase in the number of riders per capita, but Mr. Rice considers an increase in the population the most probable cause, as will be explained later. The growth of the travel in the boroughs separately has not always been parallel with that in the whole city, as was notably the case during the last three years. During 1902 and 1903, the increases were practically uniform in each borough. During 1904 and 1905, with the travel in the whole city still increasing at a uniform rate, there was a loss in the rate of increase in the travel in Manhattan, and a corresponding gain in all the other boroughs, but mainly in Brooklyn. This may be accounted for by a temporary movement of some of Manhattan's population to the other boroughs. The only reason that can be ascribed for this migration was the interference with travel in Manhattan due to the building of the subway. In 1906, when the notable increase in the number of paid passengers in the whole city occurred, there was a general increase in the rate of travel in all the boroughs. This was a greater rate than had prevailed during any of the preceding years which have been considered. Manhattan recovered more than was lost during the years 1904 and 1905. All the other boroughs made material gains.

In the upper portions of Manhattan a territory which was not conveniently accessible before the subway was opened, a great many apartment buildings have been erected. There has been a large movement into this district, the subway stations located here alone have handled nearly 8,500,000 passengers during the fiscal year of 1906. Assuming that most of these people have come into the city from the outlying suburbs in New Jersey, Long Island and Westchester, a total of nearly 17,000,000 additional passenger fares are accounted for on the subway alone.

It would appear, therefore, as already stated above, that the pronounced growth in 1906 in the total number of paid passengers traveling in the whole city, can only be accounted for by a corresponding increase in the city's population. This is probably due to the operation of the city's first subway, a great many suburban people having been induced to come into the city in view of the increased facilities afforded.

In the Borough of Richmond 15,571,889 paid passengers were carried during the fiscal year of 1906; 8,957,414 of these were carried on the surface lines, the remaining 6,614,475 on the steam roads; the daily average was nearly 43,000. During the last five fiscal years the number of passengers carried increased at a fairly uniform rate. The total increase for the five-year period was about 28 per cent. This borough now has on an average about two inhabitants to the acre. It is estimated that its population may be about 100,000 in 1916, or a little less than three to the acre. Approximately 60 per cent. of all the passengers in Richmond, about 26,000 per day, are now transported to and from Manhattan by ferry. The increases in population and passengers transported will probably be greater than indicated above. However, assuming that the same rates are maintained, in 1916 there should be approximately 26,000,000 paid passengers carried in Richmond. About 15,000,000 of these will have to be provided with transportation to and from Manhattan. Each inhabitant of the borough now rides 210 times per year; in 1916 he would ride about 260 times. There are now 130 miles of single track operated in Richmond. The transportation problem here can be taken care of for many years to come by the natural expansion of the present systems to develop new territory and an increase in the car mileage to meet the added demands of the growing population.

In the Borough of Queens the conditions are somewhat similar to those in Richmond, except that the population is larger and has increased about twice as fast. In 1906 the population was 208,596. The completion of the tunnels now under construction will probably cause a phenomenal growth in the population. Based on a normal ratio of growth, however, it is estimated that it will be about 300,000 for 1916. In studying the traffic the Long Island Railroad has not been included. There were 22,115,729 paid passengers riding on the surface lines during 1906, an increase of nearly 100 per cent. during the five fiscal years, as against the 28 per cent. increase in Richmond. The number of rides per inhabitant is smaller in this borough than in any other. In 1901 there were 73 per capita per year; in 1906, 106. If the traffic increases as rapidly during the next decade as it has during the past five years, in 1916 the travel in Queens Borough will equal over 88,000,000 paid passengers. To carry this traffic within the borough, as was the case in Richmond, it will only be necessary to increase the car mileage as occasion demands, and to add to the trackage in undeveloped territory. This does not dispose of the passengers whose objective point is Manhattan; these must be provided with facilities for crossing the East River.

The statistics are not directly available from which the number of people bound to Manhattan can be determined. It has been estimated, however, that about 60 per cent. of the riding passengers both in Richmond and in Brooklyn cross to and from Manhattan each day. Using this same ratio, then about 53,000,000 people, exclusive of Long Island Railroad passengers, will have to be transported across the East River from Queens in 1916, either by ferries, bridges or tunnels.

The Blackwell's Island bridge and six tunnels are now being constructed between Manhattan and Queens. Two of the tunnels enter Manhattan at 42d St. and are known as the Belmont tunnels; the other four are the Pennsylvania tunnels through 32d and 33d Sts. The bridge provides for two elevated and two trolley tracks; in all there will be five tracks in each direction. The Pennsylvania tunnels will probably be used mostly by Long Island commuters. If these tracks are omitted from consideration three tracks in each direction will still be available for the use of this borough. These facilities should be in operation within four years. Their combined maximum capacity should be over 133,000,000 per year, with a maximum hourly capacity of over 73,000 in one direction. If all passengers are to be provided with seats then the above figures would become approximately 60,000,000 and 33,000, respectively. The residents of Queens will therefore have ample facilities for reaching Manhattan for many years to come.

During the fiscal year of 1906 389,555,025 paid passengers were carried on the street railways in Brooklyn Borough, a daily average of over 1,067,000. This represented 278 rides per inhabitant for the year. The elevated lines carried 125,221,831 and the surface lines 264,333,194, or about 32 and 68 per cent., respectively, of the total number. Over 60 per cent., or approximately 234,000,000, of all of the above passengers were carried to and from Manhattan over the bridges and ferries. There has been a slight increase each successive year in the rate of increase of the total passengers carried.

Considered separately, the riders have increased faster on the elevated than on the surface lines. The number of surface riders in 1906 was about 27 per cent. greater than in 1901. During the same period the amount of single track operated has increased less than 2 per cent., and the car mileage only about 11 per cent. This has resulted in a greatly increased crowding on all lines. For the same five fiscal years the population has grown less than 18 per cent. Each inhabitant has taken 189 rides on the surface cars during 1906, as compared with 174 rides during 1901.

If the same rates of increase which have prevailed during the past five years are maintained for a decade, in 1911 the number of paid passengers carried on the surface roads in Brooklyn will amount to about 336,000,000; in 1916, to about 426,000,000. These figures do not represent the maximum rates at which passengers will have to be carried during the rush hours. During these hours it is estimated that transportation will have to be provided on the surface lines at the rate of over 100,000 per hour in one direction in 1911, and 140,000 per hour in 1916.

The travel on the elevated railroads in Brooklyn has very nearly doubled, while the surface roads were gaining 27 per cent. To carry this enormous increase of traffic only 9.346 miles of single track have been added, or only 11 per cent. more than was operated in 1901. The car mileage during the same period has not increased 60 per cent. It appears, therefore, that the increase in facilities on the elevated railroads has not kept pace with the growth in the traffic. The whole transportation system, both surface and elevated roads, is greatly overburdened. It is obvious that in order to provide relief for Brooklyn's population the subway systems must be extended into and through the borough as quickly as possible. When this is done the surface lines will be greatly relieved; they can then be depended upon to fulfil their proper functions; this is, furnish the necessary short-haul service. Long-distance passengers will be provided for on the elevated and subway lines. The capacity of the present surface and elevated lines is about 280,000,000, if moderate crowding is permitted during the rush hours.

From careful estimates it is believed that not far from 560,000,000 paid passengers will have to be provided with transportation in Brooklyn on all lines during 1911, and 800,000,000 during 1916. Deducting the capacity of the present facilities, subways should be built by 1911 to accommodate 280,000,000 people, and by 1916 520,000,000 people. To furnish this service with only moderate crowding, one four-track railroad operating ten-car trains should be completed across the East River and into Brooklyn within the next five years; and one more within five years afterwards, or two altogether during the next decade.

If, however, all passengers are to be provided with seats during the rush hours new subways must be provided for 370,000,000 passengers by 1911, and 610,000,000 by 1916, or two four-track railroads must be constructed to Brooklyn within the next five years, and four within the next decade.

The population of Bronx Borough at the end of the fiscal year 1906 was 288,417. It has grown over 38 per cent. during the last five fiscal years. During the same period the number of paid passengers carried on the surface lines, or, it may be said, the travel within the borough, has increased at a uniform rate of more than 36 per cent. The corresponding increase in the passenger car mileage has been less than 27 per cent., consequently the service now provided is not as good as it was five years ago. The trackage is sufficient, and adequate surface car transportation in this borough can be furnished for some years by increasing the car mileage or number of cars in use.

The elevated and subway traffic in the borough represents the travel to Manhattan. The number of paid passengers using the elevated road increased at a uniform rate up to 1904. The next year there was a very slight increase, due wholly to the opening of the West Farms branch of the subway, which had been in operation for seven months. In 1906 the use of the subway caused a falling off in the number of elevated passengers. Apparently the subway has had no effect upon the travel on the surface lines in the Bronx. Probably about 42,000,000 paid passengers will be carried on the surface lines in 1911, and 57,000,000 in 1916.

Manhattan's population was 2,167,585 for the 1906 fiscal year. This represented an increase of about 15 per cent. in five years. The traffic on all the lines in the borough has increased nearly 39 per cent. during the same time, but the growth has not been uniform throughout the whole period. The percentage of increase for each succeeding year was less than that for the preceding year up to 1905. For 1906, as already stated, there was a marked increase in the travel on all lines. While in each year the total travel has increased over that of the preceding year, the same thing cannot be said of the surface, elevated and subway lines, when considered separately. During 1902 and 1903 there was a steady increase in the number of paid passengers carried on both the surface and elevated roads. In 1904 there was a falling off on the surface lines and a corresponding increase on the elevated lines. This was probably due almost entirely to the interference with the surface cars caused by the construction of the subway. But the surface and elevated lines showed a loss in 1905, which combined was equivalent to the travel on the subway during that year. Most of the subway passengers, however, were drawn from the elevated lines. There were nearly 21,000,000 less passengers using the elevated than in 1904—a loss of 10 per cent., instead of what should have been a gain of nearly 20 per cent., due to the subway travel. During 1906 the surface roads gained a little over the previous year, but the elevated roads continued to lose passengers.

In the fiscal year of 1906 the surface cars in Manhattan carried 391,354,877 paid passengers. This was a total increase of about 7 per cent. in five years. It has already been shown that the population of the borough increased 15 per cent. during the same period. Each inhabitant rode 194 times during 1901, as compared with 181 times in 1906. It is, therefore, apparent that the public is not riding on the surface cars as often as formerly. There are several reasons for this. The subway traverses a section of the city which had not formerly been provided with rapid transit facilities; therefore, those who had been compelled before to use the surface cars immediately changed to the subway. Again, a great many have moved their homes from lower Manhattan into upper Manhattan and the Bronx, and in consequence have become patrons of the elevated and subway roads. The number of passengers carried in 1906 does not represent the maximum number carried per year during the last five years. In 1903 there were 396,570,435 surface car passengers, amounting to nearly 200 rides per capita. This was the summit year of the surface car travel. The changes in the trackage and car mileage have not corresponded with the variations in the traffic. The former has increased about 14 per cent., but the latter only about one-half of 1 per cent. The density of traffic, or number of paid passengers per car mile, has increased over 6 per cent.

At present, if there were greater facilities for the long-distance travel, the traffic on the surface lines would be materially less. The surface lines should be wholly available for the short hauls. If the traffic growth on these lines for the five years just past is maintained for a decade the paid passengers would then be about 419,000,000 in 1911, and 448,000,000 in 1916. This number can probably be taken care of on the present surface lines without excessive overcrowding, provided the street conditions are so regulated as to reduce to a minimum the obstruction to car movement, and the size of all the cars in service is increased to the dimensions of the largest cars now being used. It would be of great benefit if the movement of vehicles on the car tracks were prohibited, or at least restricted, particularly during the rush hours. Careful investigations made by the Merchants' Association during 1903 confirm these statements.

It has already been pointed out that a large number of former patrons of the elevated changed to the subway as soon as it was opened. The elevated and subway roads in Manhattan are considered together, since they both provide for the long-distance travel. The combined traffic on the two systems during the fiscal year ending June 30, 1906, was 355,331,924 paid passengers, 227,538,369 riding on the elevated roads, and the remaining 127,793,555 using the subway. In five years the number of long-distance riders has increased over 108 per cent. The number of such riders per inhabitant has been 91 for 1901, and 164 for 1906. The enormous gain indicated above was accompanied by a corresponding loss on the surface lines. It is unlikely that such an increase in the elevated and subway traffic will be maintained for more than a few years at the most; it merely represents a change from one system to another. The more nearly correct conditions will be shown in the increase in traffic on all lines. Moreover, since Manhattan and the Bronx are interconnected by both the elevated and subway lines, it will be desirable to consider these two boroughs together in arriving at any conclusion relative to the traffic on these two systems.

The population of Manhattan and the Bronx has been estimated at 2,456,002 for the fiscal year 1906. It will probably be about 2,740,000 in 1911, and 3,170,000 in 1916. The total paid traffic for the last five fiscal years has increased about 41 per cent., to 818,273,413 per year, or an average of about 2,242,000 per day. The number of rides per capita is now about 333. The above total paid passengers are distributed as follows: Surface lines, 422,567,025; elevated lines, 257,786,756; subway, 137,919,632. The surface lines carry about 52 per cent. of the total traffic and the elevated and subway lines together the remaining 48 per cent. It appears, therefore, that at present in

Manhattan and the Bronx the traffic is about equally divided between the surface roads in one case and the elevated and subway in the other, while in Brooklyn and Queens only about one-third of all passengers were carried on the elevated lines.

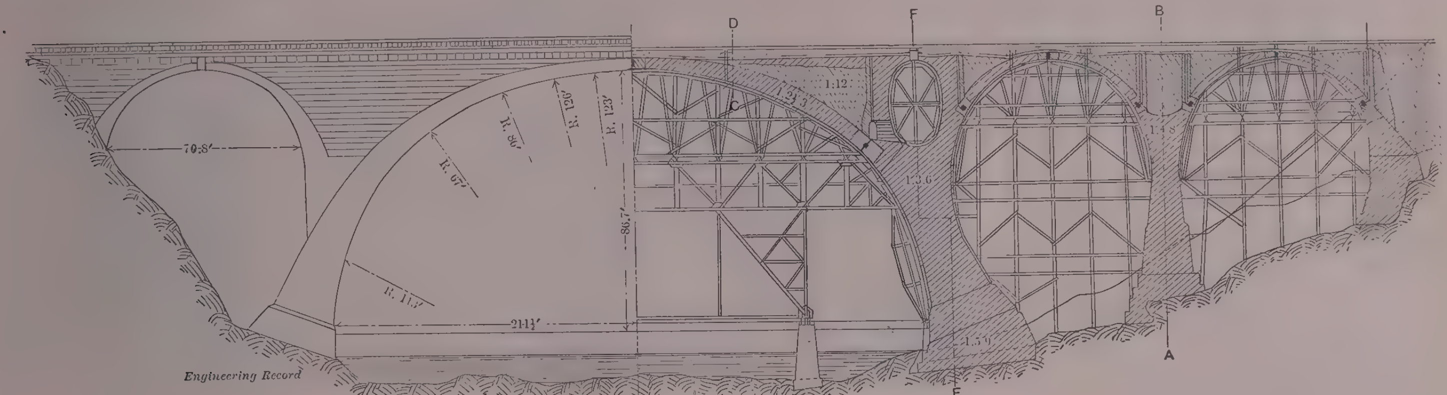
At the 41 per cent. rate of increase for five-year periods the total traffic in Manhattan and the Bronx will be about 1,153,000,000 in 1911 and 1,626,000,000 in 1916, daily averages of 3,131,000 and 4,454,800. Transportation must be provided for the rush hour conditions, or maximum number carried in one hour in one direction. The capacity of the existing elevated and subway roads, based on such conditions, if all passengers are to have seats, is not far from 200,000,000 per year; if moderate crowding is to be permitted, about 300,000,000. The estimated number of surface car riders has already been stated—for Manhattan, as 419,000,000 in 1911, and 448,000,000 in 1916; for the Bronx as 42,000,000 in 1911, and 57,000,000 in 1916. Deducting these figures and the estimated capacity of the existing elevated and subway lines from the total estimated traffic to be taken care of in 1911 and 1916, we have either, when seats are furnished, 492,000,000 and 921,000,000, or, with moderate crowding, 392,000,000 and 821,000,000 passengers, respectively, for whom transportation must be provided in new subways yet to be constructed.

Under moderate crowding two additional subways must be completed within five years and four within ten years. If seats are to be provided three additional four-track subways will have to be put in operation within the next five years, and three more within a decade, in order that the inhabitants of Manhattan and the Bronx may be transported to and from their daily business in comfort and decency.

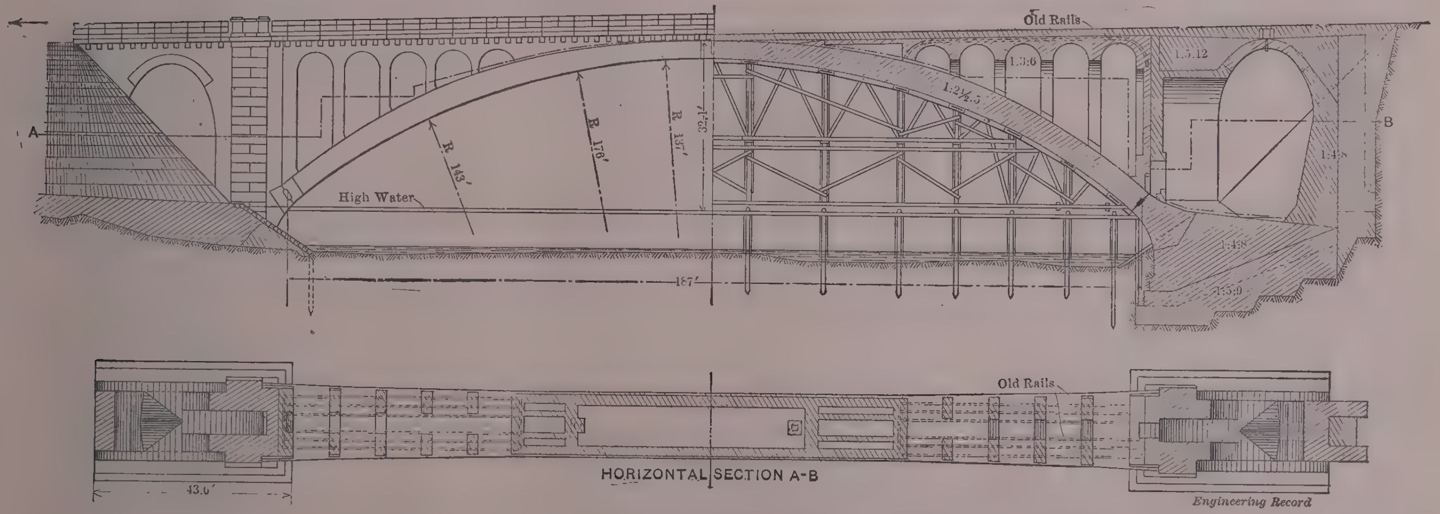
The Railway Arches of Concrete at Lautrach and Kempten, Bavaria

Three long-span, three-hinge concrete arches without reinforcement have recently been built in Bavaria across the Iller, a tributary of the Danube River. One of them at Lautrach carries a single track of the Memmingen & Legau R. R. at a height of about 40 ft. above the water, and consists of two side arches and a main arch of about 187 ft. clear width, and 32.2 ft. rise. The bridge is about 13¾ ft. wide over all, and has a solid concrete floor with longitudinal jack arches supported on transverse spandrel arches between the haunches and the skew-backs. Just above the crowns of the jack arches the floor is reinforced by seven longitudinal lines of old rails which are bent downward at both ends.

The curve of the intrados is described with three radii of about 137 ft., 176 ft. and 143 ft. respectively, counting from the center toward the end, the radius of the extrados was 158 ft. The crown was computed to have a vertical displacement of about 1.6 in. for a range of temperature of 40° Cent. The arch has three cast-steel hinges with T-shaped vertical transverse sections. The live load used in the calculations was 2,860 lb. per foot for locomotives, and 2,340 lb. for cars. Ordinary concrete was assumed to weigh 150 lb. per cubic foot and the lean concrete filling 100 lb. The bridge cost 91,000 marks, while the estimated cost of a corresponding steel bridge was 110,000 marks. The concrete in the floor and in the skew-back bearings was proportioned 1:3:6; in the arch ring, 1:2½:5; in the abutment arches, 1:2:8; in the abutment footings, 1:5:9; and in the fill over the abutment arches 1:5:12. The concrete floor was waterproofed with asphalt and covered with about 1 ft. of ballast. The arch was constructed on a center made of twelve unequally spaced transverse bents with scarf boards supported intermediately by knee-braces. The centering was built in two stories and was carried on pile falsework without longitudinal bracing.



Elevation and Longitudinal Section of the Railway Bridges at Kempten.



Plan, Elevation and Longitudinal Section of Railway Bridge at Lautrach.

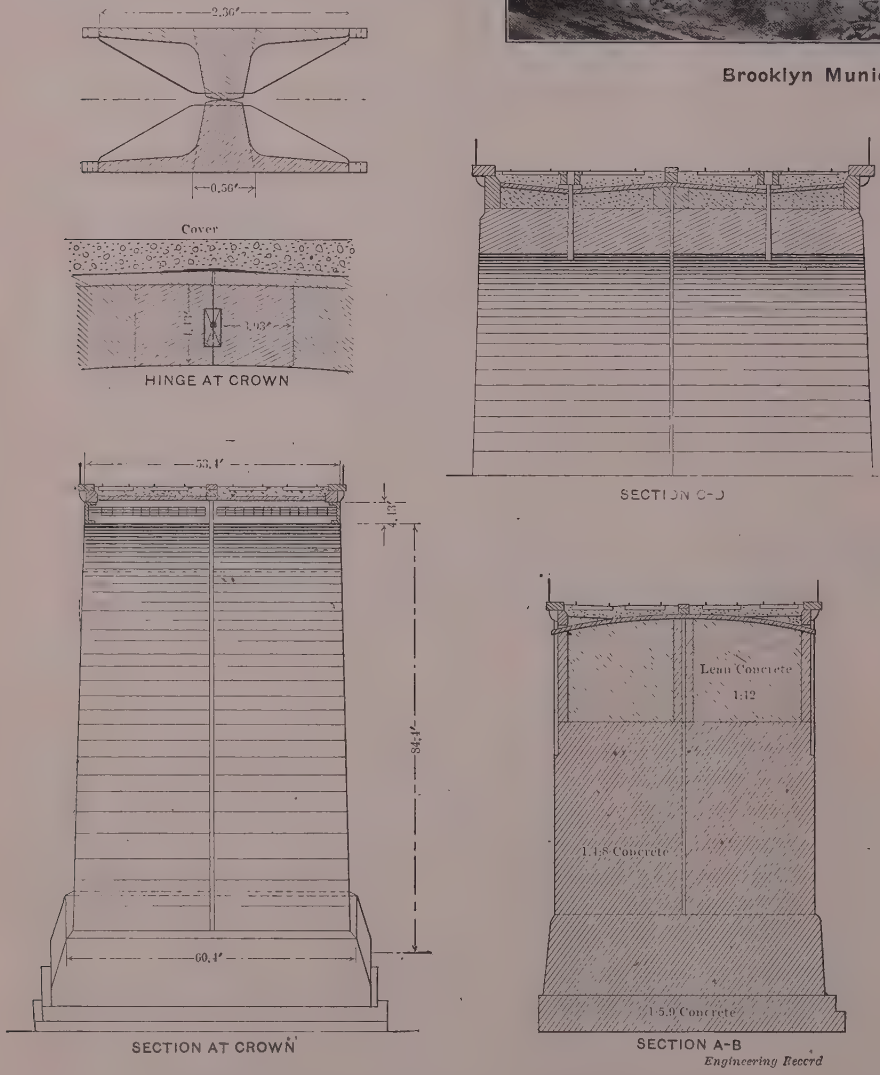
Two bridges near the station at Kempten have a channel span of 211½ ft. with a rise of 86.5 ft., flanked by three smaller arch spans. One bridge is a double-track structure about 25½ ft. wide, and the other is a four-track structure 53½ ft. wide, which consists of two separate bridges about 2½ in. apart, each closely resembling the double-track structure. The main arches are of the surbase type, with the lower ends integral with the abutment piers from the springing line up to a point near the haunches, where the skew-backs are placed overhanging the face of the abutment piers. This reduces the span between the skew-back hinges to about 166 ft., with a rise of 29 ft. The arch ring has a thickness of 4.42 ft. at the crown and 6.07 ft. at the haunches. It is made with 1:2½:5 concrete, while the proportions in the other parts of the structure are 1:3:6 in the lower part of the abutment, 1:4:8 in the upper part of the abutment, 1:5:9 in the footing.

Between the longitudinal face walls about 24 in. thick, the spandrels are filled with 1:12 cinder concrete up to approximately the level of the crowns of the arches, where the surface is pitched longitudinally and transversely for drainage through center outlets and is covered with 8 in. of rich concrete and 24 in. of ballast, on which the tracks are laid. The bridge is proportioned for a locomotive load of 5,330 lb. per foot, and a train load of 2,500 lb. per foot on each track. The maximum working stresses on the concrete are 497 lb. per square inch in the main arch, 369 lb. in the small arches, and 270 lb. in the foundations where the pressures transmitted from the footings to the hard marl is reduced to about 8 tons per square foot.

The cast-steel hinges are formed of two T-shaped pieces which are placed together so as to have an H-shaped cross-section, the bearing surface being at the center of the horizontal bar of the H. They are set in blocks of 1:2:2 concrete which had a strength when 24 days old of about 6,800 lb. per square inch, but is loaded to a maximum of only 938 lb. The hinges of the small arches are concrete blocks spaced with sheets of lead ¼ in. thick, which have a crushing strength of about 7,440 lb. per square inch, and are only loaded to about 412 lb. at the crown and 682 lb. at the skewbacks. The main arches are made of 1:2½:5 concrete with a strength of about 4,140 lb. per square inch, and are designed not to have the full loads applied to them under one year when they should develop a factor of safety of about eight. The total cost of the bridges at Kempten is about 1,156,000 marks and the estimated cost of a corresponding steel bridge was 1,420,000 marks.

The centering for the side arches was of ordinary construction supported on framed trestle bents and piles. For the main arches this was of special construction supported on steel trusses about 16 ft. deep and about 195 ft. long, carried by trussed steel bents nearly 40 ft. high, supported on temporary intermediate concrete piers about 121 ft. apart. The ends of the trusses cantilevered equally beyond their supports and were made to correspond with the arch curves in the face of the abutment, from which they received the thrust. The forms between the springing line and the lower chords of the falsework trusses were supported on inclined timbers extending from the abutment base to the trusses.

The main falsework trusses carried nine bents of wooden falsework with vertical and inclined posts supporting the scarf boards at panel points and intermediately. The two longitudinal halves of the four-track bridge were built separately, and after the second one was six weeks old, the centering was struck by gradually slacking off the 30-ton jacks from the center toward both ends. The 250-ton falsework was then moved about 200 ft. to the site of the double-track bridge where it was revolved 30 deg. and raised about 6 ft. to the required position. The bridges were designed by Mr. Beutel, Chief Engineer of the Bavarian Railroads, and were described in a recent issue of the "Genie Civil," of Paris.



Details of the Four-Track Twin Bridge at Kempten.

A New Municipal Asphalt Plant.

The asphalt plant now being erected for the Bureau of Highways, Borough of Brooklyn, New York, in the corporation yard at the Seventh St. Basin on the east side of the Gowanus Canal, will have a normal capacity of 270 cu. ft. of wearing surface material and 100 cu. ft. of binder material per hour. The driers and mixers are arranged so that both classes of material can be produced and loaded simultaneously.

Brooklyn Municipal Asphalt Plant under Construction.

The building is a fire-proof structure, having a steel frame, reinforced-concrete floors, and walls and roof of No. 26 U. S. gage galvanized corrugated iron. It is in the center of the yard, thus affording storage room on all sides, and occupies a rectangular area about 30x70 ft., the long axis lying about north and south. The main section of the building, through which two driveways pass on the ground level, is three stories high. On the second floor are two mixers, one over each driveway and each equipped with a weighing hopper to which run chutes from the hot sand, hot stone and dust bins on the floor above. In a one-story wing attached to the south side of the three-story part are three driers and in a two-story wing, on the opposite side, are the asphalt melters and the power equipment.

The driers, the mixers and the bucket elevators, with which sand, stone and dust are handled, are operated with power supplied by a 50-h.-p. Erie engine of the balanced valve and automatic cut-off type, to which steam is furnished by a 65-h.-p. Star watertube boiler. An 8-h.-p. Sturtevant vertical engine is used to drive the mechanical agitators in the melting tanks, and a Knowles 6x8x12-in. air compressor, which will be referred to later, is also installed. The engine and boiler foundations were built by the Bureau of Highways. As the site is all made land, the top 5 ft. of which is mainly ashes, 30 ft. piles were driven to a solid bearing and the concrete laid over these.

The sand and stone driers are of the rotary cylindrical type, in which the material passes through a slowly revolving drum, while the products of combustion pass along the outside of the drum in the same direction that the material flows and back inside the drum in the opposite direction. The three driers are placed with their longitudinal axes parallel to the longitudinal axis of the building, the fire boxes being at the extreme south end of the south wing. The boiler plate shell which surrounds the drum is 50 in. in diameter and about 20 ft. long, including the portion over the fire box, which has a length of about 10 ft. The drum is 40 in. in diameter and has a slight pitch toward the outlet end, which is open so that the sand or stone falls from it into a chute, connected to the underside of the front end of the shell, through which it flows to the bucket conveyor.

In order to prevent the material from sliding around the inside of the drum, longitudinal vanes are fixed radially to the inner surface to carry the material up and couse it to fall repeatedly through the products of combustion. Forced draft is maintained by a blower which exhausts the gases at the rear end of the drum. The driers are built entirely of steel and iron and require no brickwork except the linings for the fire boxes. The undried sand and stone is delivered to the drum by a bucket conveyor served by shovels from the storage piles. The drums are driven with gearing from a line shaft and have a speed of about 20 r.p.m. Material passes through these driers in about six or seven minutes.

The three cylindrical melting tanks, which are of the direct heated and mechanically agitated type, are placed along the west side of the north wing. Each tank is connected with the air compressor before mentioned and is equipped with a 4-in. stand pipe leading up through the second floor. The melted asphalt is forced up into the stand pipes by compressed air and may be drawn off through a stop cock into either of two buckets which run on trolley tracks leading to either mixer. These trolley buckets are operated by hand and have spring and dial scales so that the proper amount of asphaltic cement can be readily measured. A barrel elevator is used for hoisting the cold asphalt to the second floor of the north wing.

The operation of the plant and the work done with the material it produces will be in charge of an assistant engineer of the Bureau of Highways. The plant will be under the immediate direction of a superintendent who will see that a proper mixture is made and also attend to all details connected with the operation of the plant. A foreman will be in charge of the labor at the plant. On the streets four gangs of about ten men each will be equipped at first, each gang in charge of a foreman. Twelve special wagons, made by the Shadbolt Mfg. Co., and four 5-ton Iroquois steam rollers, have been purchased for use on the work. An application has been filed by the Bureau of Highways with the Municipal Civil Service Commission to establish the grade of asphalt worker, so that all labor connected with the plant or the street work will be under civil service rules.

The plant is being built under the direction of Mr. Geo. W. Tillson, chief engineer of the Bureau of Highways, and under the immediate supervision of Mr. John C. Gray, assistant engineer. The Warren Asphalt Paving Co. is the contractor; Mr. H. W. Ash, mechanical engineer, and Mr. E. J. Shiland, superintendent. The contract price for the plant, except the boiler and engine foundations, is $22,485.

THE COST OF TARRING THE ROADWAY of Revere Beach Parkway near Boston is itemized as follows in a report by the Metropolitan Park Commission: There were 67,434 sq. yd. treated at a total cost of $4,494.43, or 6.66 cents per square yard. The work required 0.4032 gal. of Tarvia and 0.0147 ton of stone screenings per square yard. The Tarvia cost 2.62 cents per square yard, screenings 1.84 cents, preparing the roadway 0.86 cent, applying the Tarvia 0.57 cent, applying screenings 0.62 cent, rolling 0.47 cent. The report states that until the treated surface had passed through a winter and spring a definite opinion regarding it could not be formed, but it was satisfactory during the remainder of the year in which it was laid.

Reducing Dust and Hardening Roads by Surface Application.

Among the papers read at the recent Pittsburg convention of the American Road Makers' Association was one of Mr. J. W. Howard, the New York paving specialist, on the suppression of dust on earth, sand, gravel and macadam roads by surface applications. Where the population is dense or the traffic heavy, it is more economical to suppress dust by laying pavements more durable and less expensive to maintain under such conditions than macadam. A very large part of the highway mileage of the country will always be macadam or inferior roads, and the problem of hardening their surface is therefore an important one. The methods used are divided into six classes by Mr. Howard: sprinkling with fresh water, sprinkling with natural salt water, sprinkling with a mixture of water and calcium chloride, sprinkling with water and saponified oil, impregnating with special crude oils and impregnating with special coal tar products. Sprinkling with fresh water is too expensive for thousands of miles of roads. Water sprinkling is only a temporary help. Where done continuously it costs more than any of the other methods.

Sprinkling with salt water can be done only when the ocean is near. It is more effective than fresh water because the salt accumulates on the road and retains moisture. The accumulated salt, when dry, hurts throats and eyes, damages clothing, furniture and to some extent the feet of horses. It is a natural mixture of water and sodium chloride and thus related to the next method.

The principle of sprinkling with water and calcium chloride is that this salt is hydroscopic and when mixed into the road surface (by means of having it in solution of the water of the sprinkling cart) it absorbs additional water from the atmosphere. It also has a feeble chemical action which unites some of the silicates of the macadam. To produce the best results on macadam requires about 3 lb. per gallon of water. One test required three sprinklings the first month and two each succeeding month, or about 0.9 lb. of calcium chloride at a total cost of $0.066 per square yard, to which add labor of mixing with water and the sprinkling, about $0.04, making a total for good work of about 10 cents per square yard for an average season of nine months.

A test in the moist climate of England required one sprinkling the first month and one about every two months thereafter, and used ¾ lb. per square yard for the first application and ⅜ lb. for each subsequent treatment of the road. Another test on a road exposed to sun and wind required about 2 lb. per square yard the first day, 1.2 lb. the second day and 1.2 lb. every third or fourth week thereafter to lay the dust. This same substance, possibly modified, seems to be sold by the name Akonia. The calcium chloride method is considered a temporary help at a few points by Mr. Howard, but expensive and out of the question for general use.

A mixture of water, oil and some alkali like ammonia or potash, forming practically a liquid soap, has also been used. There are several proprietary compounds on this principle; one is called Sandicize, patented and tried in Scotland. It consists of grease from wool washing and some potash. There is also a patent Dustroid in England which has been tried, and which is believed to be on the same principle. Another compound, seemingly of the same nature, for mixing with water in sprinkling wagons is known as Westrumite. A trial of this material was made in South Park, Chicago, in 1905; a five per cent. solution was sprinkled every eight days; it required 0.17 gal. per square yard and cost $0.0064 per month or $0.0512 per square yard per season of eight months. On the same road water alone cost $0.00415 per month or $0.0313 per square yard for a season of eight months. This cost included everything except the water, which is free for sprinkling in Chicago, but would have been added in most places.

Another compound of oil and alkali called Pulverite was tried on the Auverne roads in France and irritated the skin, throat and eyes. Rapidite is another French compound of asphalt powder and water, like a thin mortar on the surface, but is of doubtful value. All these soapy compounds are of but temporary benefit in Mr. Howard's opinion, but have their use on gravel and macadam in a limited number of places. Where climate is so variable, distances so great and labor so high, as in America, he believes it is necessary to seek substances for laying dust which last longer and need attention only at long intervals.

The application of certain oils to roads practically began in California in 1894 when crude oil from the Summerland oil wells was used on the Ortaga road, five miles from Santa Barbara. It was sprinkled to lay the dust of the soft soil of the road. A slight hardening of the road was observed from the repeated applications of the thick maltha or asphaltic oil. A few other roads in California were sprinkled until about 1900, when the use of its oils on roads rapidly extended from the many oil centers in that State, until today oil is used for suppressing dust and hardening roads, with varying success and failure, in about 40 counties of California to an extent of a little more than 2,056 miles. California and other crude oils are now being used experimentally to a limited extent in other States and in Europe. Persons who have not seen the peculiar local California conditions, as its climate, long dry season, roads of dry volcanic or alluvial dust, sand, clay and loam, and roads made of these materials saturated with the peculiar maltha or thick, sticky asphaltic oils, must not assume that they can use crude oils in the same way and with the same results on other kinds of roads, with heavier traffic and in climates with rain at short intervals and frosts in winter. California crude oils and a few others, with marked exceptions there and elsewhere, contain maltha or soft asphaltum, and resemble thick, sticky molasses. Such oil is almost a liquid asphalt, and when heated and spread upon certain soils will impregnate or can be harrowed into them. They are then rolled and compressed by traffic and will consolidate and form a pliable crude asphaltic crust. Oil must be applied at intervals thereafter and no water must get into the yielding subsoil under this weak bituminous or asphaltic crust.

In Contra Costa County, Cal., some macadam roads were oiled with 12° to 18° Beaume oil, costing 65 cents per barrel, and applied to the road cold, cost about $75 per mile. It was not satisfactory. It does not help macadam as much as more absorbent soft roads.

Kings County, Cal., has about 40 miles of oiled sandy roads. Long stretches became ground up and gave off dark dust. It is necessary to oil these roads constantly to such a degree that wheels and horses throw up the surface and occasional rains wash away the oil and road. Still it is better than no oil because it hardens the sand and permits faster travel and heavier loads.

In Sacramento County, Cal., Mr. Howard noticed that the thick, sticky oil helps gravelly, clayey and sandy loam roads and macadam, but does not give as clean, smooth surfaces as are found in many States having better constructed roads from better materials.

Probably the best constructed and maintained oiled road of California is the driveway of Golden Gate Park, near San Francisco. The oil when cold is between 14° and 16° Beaume. It was heated to about 300° F., sprinkled while hot on the road; men followed closely and stirred the oil into the road with rakes. The road of course was first properly graded and shaped. Its surface was made smooth, then soaked with water to loosen it. It was next well dried to a depth of at least 1 in. and the oil applied as stated during warm, dry weather. Repairs are constantly made by promptly sweeping out any little hole that forms, putting in a little oil, adding gravel and stone dust to absorb the oil and tamping until firm. The oil costs 72 cents per barrel and 400 barrels per mile of 16-ft. road were first applied. Since then 300 barrels per mile have been applied twice each year, or 600 barrels per year. There is a tendency toward the formation of ruts and a slight lowering of the whole road surface. This last is caused by rain water working through the surface and carrying away the road material from under the asphaltic oil crust. Although expensive, it is so important a drive out of San Francisco that it is worth all it costs.

Kentucky oil was used in Fayette County, Ky., in 1904, 1905 and 1906. At least three oilings were needed the first year and cost a little more than six cents per square yard. At least one oiling per year for light travel costing about three cents and two oilings per year for numerous travel at about five cents, will be needed. It is too soon to report on the efficiency and economy of this oil and work.

Near Jackson, Tenn., during 1905, a crude oil was used with a flash point 169° F., specific gravity 0.92. It was applied to a road 18 ft. wide and covered about one-half mile. The labor cost $.0057 and Mr. Howard estimates the crude oil f.o.b. station Jackson would cost about 7 cents per gallon. Thus 0.48 gal. per square yard would cost $0.0336. The total cost of oiling, therefore, was about $0.0393 per square yard for one application. The oil soaked into the macadam left no coating on top and when examined 7 months later it was of no permanent benefit to the road and had ceased long before to suppress dust. The process should have been repeated at least three times the first year and twice per year thereafter.

A heavy residuum oil left after evaporating the lighter oils was also tried near Jackson. It had a flash test of 308° F. and a specific gravity of 0.97. The labor for applying this heated oil cost $0.0078. Mr. Howard estimates the cost of 0.71 gal. per square yard at 7 cents per gallon to be $0.0497, making a total of $0.0575 per square yard for one application, including cleaning the macadam and spreading sand on top of the heavy residuum oil. When examined 7 months later a layer of compacted dust about ⅛ in. thick remained while some of the road surface had been washed and some blown away. This surface should have received a second treatment within the first three months and probably two per year thereafter. Then some conclusion would be possible on what now appears not to be a success.

Liverpool, England, in 1902 and 1903 tried an oil on some suburban macadam and found that it cost less than constant water sprinkling; but the kind of oil used made the surface of the road oily and slimy in dry weather and more so in wet weather, and of offensive odor. Its use was stopped as well as that of previously used calcium chloride solutions in watering carts. The solution pleased them better than oil, but proved too expensive for suburban and country use.

Mr. Howard learned from California practice that the crown of a road of soft materials (for it is doubtful if any crude oil really helps macadam) to be oiled must be high and its sides well drained because water with or without freezing floats much of the oil away or gets under the oiled crust and softens it. The hotter the applied oil the warmer the weather and dryer the road, the better. When heating crude oil it is necessary to allow for an expansion of 15 per cent. It should be heated between 225° to 300° F., oil of 14° to 16° Beaume and containing at least 35 to 50 per cent. of thick maltha or liquid asphalt, should be used. It should contain not over 3 per cent. of foreign matter and water, and the balance should be light bitumens, some of which should oxidize and some evaporate from the freshly oiled roads, leaving an elastic, dustless crust of road material and heavy parts of the oil. Oiling by hand is expensive and not uniform, especially when it must be done by the mile. Special machines for oiling, harrowing, spreading sand and other operations, are to be had, although still imperfect.

In California, according to soil, from 175 to 400 and sometimes 600 barrels of 42 gal. each of asphaltic oil are needed per mile of 10 to 16-ft. road per year. Two or three treatments are needed on a new road during the first year, if the road is of a loamy or sandy nature. After a road in California has been well oiled and a crust is formed care must be taken not to break through the crust. Prompt repairs are imperative. It is undesirable to flood the road with oil, and it is better to use several successive applications. An excess of oil on a road is disagreeable and will injure the paint of vehicles, harness, clothing and seems to affect rubber tires.

Road materials, which if wet would pack firmly under a roller or traffic and still remain slightly porous, are the materials which are the best for use by saturating with suitable thick adhesive oils. Such oils suppress dust and harden such a road. Road materials of certain clays, earths and gravels which pack tight when wet, or bake in the sun and pulverize into dust, must be either loosened up by harrowing or otherwise made porous before being oiled, and then must be covered with sand, screenings or the material of the road. Oiling roads is a case where a little knowledge is dangerous, and where much knowledge and experience must be employed to select suitable oils and to use them correctly.

In regard to the suppression of dust by means of oils, it is impossible to prescribe any formula. There are a great many kinds of oils produced by nature. The naphtha or light oils of Russia and the paraffin oils of Pennsylvania, Ohio and elsewhere will not do and Mr. Howard doubts if any of their products can be successfully and economically used. The Texas, Kentucky, Kansas oils and some others may possibly be used if specially prepared or applied in special ways. The California maltha or asphaltic oils are successful with loamy, sandy and alluvial soils in that and like climates, but not yet with macadam. Transportation is likely to prove too expensive for those and other suitable oils elsewhere than near their sources of production. The use of a crude oil is a local question for each place and requires careful investigation and the best of advice before undertaking its use; also careful supervision when used and instruction as to prompt repairs.

The use of coal tar and its products as ingredients of pavements and roads has been undertaken in many ways for about 50 years, but with no success until quite recently. It is used in the general group of pavements called tar-macadams, composed of hot crushed stone and specially prepared tar or bituminous cement mixed while hot and compressed in place. Of this group that which is known as bitulithic pavement seems the most successful, for streets and in lighter form, known as bitrock, for suburban roads and the interior of villages and small towns.

The difference between a tar-macadam and tarring a macadam road is important. A tar-macadam is a mixture of heated crushed stone and specially prepared adhesive tar-cement mixed by machinery, spread and compressed. The best type of a tar-macadam at present is considered by Mr. Howard to be that devised by the late F. J. Warren. He made it clear that not only his pavement but that all macadam pavements should have voids between the larger crushed stone so filled with smaller and smaller broken stones that they mutually sustain themselves in position as a solid mass and do not depend upon the adhesion of the tar product or any binding substance to hold them in place. The cement acts simply as a final filler of small pores and a waterproofing material within and upon the macadam.

The tarring of a macadam road means sprinkling, painting or covering its surface with soft tar specially prepared for that purpose, and which will penetrate the macadam and make it waterproof and retard the formation of mud and dust. A prepared tar which is sufficiently fluid to lay dust and penetrate the surface of the macadam cannot be a binding material to hold together any portion of that macadam except the finest particles and dust.

The surface application of specially prepared coal tar to eliminate dust and make macadam waterproof and more durable first succeeded in Melbourne, Australia, in 1886, where the experience gained has been followed by constant use ever since. Tar freed from water and very light oil and otherwise improved is used. The macadam is first well bonded and consolidated, then tarred, and fine stone screenings are spread. Coal tar products are suited only to hard macadam and similar roads because it is not practical and economical to use these products on soft earth, clay and sand roads. The cost would be too great and the roads would not harden. It is better and cheaper where obtainable to use suitable asphaltic oils on soft and absorbent roads as is done in California.

Near Fontainebleau, France, the road to Paris was tarred during 1903, 1904 and 1905. The cost of repairs and renewals is less than by the old methods without tarring. The repairs to the macadam itself are reduced to about one-fifth of what they were. The tarred surface produces little dust.

The Vendee District, in France, where such work began in 1896, furnishes the following record: One highway 20 ft. wide had its macadam put in good condition, well rolled and used by traffic for a month; then thoroughly cleaned by stiff brooms followed by fine brooms. Hot tar was spread over the macadam. It percolated down into the macadam, the work being done in warm weather with the road very dry. It penetrated 1 in. in 4 hours and 1⅔ in. in 24 hours. The first tarring required about 1.9 lb. per square yard. Twelve hours after tarring each section, clean sand was spread. The surface was then rolled and opened to traffic.

One year later the operation was repeated, using less tar because the road would absorb less; then every second year thereafter. The road was practically free from dust, its wear was reduced to about one-half and the total cost of the road in 10 years was 40.4 per cent. less than under the old system of maintaining the road in constant good condition with macadam only. This was due principally to the fact that the tar saved $1,430, which would have been paid out during the 10 years for extra crushed stone and resurfacing, if the surface had not been tarred at intervals as stated. Tarring made it necessary to resurface with stone only once, not twice as formerly.

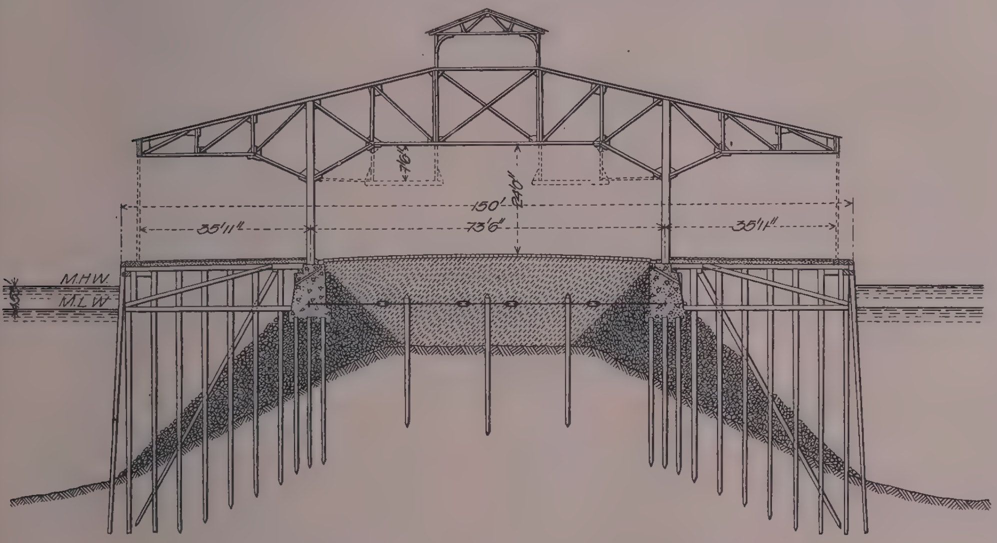
A second road in the same district properly tarred costs 23 per cent. less on a basis of 14 consecutive years than if it had been maintained with macadam only.

A section of macadam road near Paris shows that the tarred section needed only one cleaning in the winter of 1902-3, when 2⅔ cubic yards of mud were removed from 1,131 square yards of surface of tarred section, whereas 32 cubic yards of mud were removed by nine necessary cleanings from the same amount of surface of untarred macadam on the same road under the same conditions of traffic.

In the Department of the Seine-et-Marne, France, which Mr. Howard has twice visited, the expense of using special hot tar and employing every precaution and all the skill possible, is warranted by the results. The experience here indicates that the tar should not be applied to old irregular macadam without first putting it in good order and having it thoroughly rolled and under traffic and weather for at least a month; also that newly constructed macadam roads should be thoroughly compacted by rolling and open to traffic and weather for a month or more before being tarred. Reliance is not here placed upon the tar to bond the macadam together, but simply to agglomerate the fine particles in the small pores of the macadam and make its surface waterproof.

Near Liverpool, England, tar painting, as it is called, is used where the traffic is light. The macadam is first cleaned then painted, then covered with grit, and allowed to stand two or three days to soak. It is then consolidated with steam roller and traffic admitted. This suppresses the dust and gives longer life to the roadway with acceptable hygienic and economic results.

Holyhead Road, England, was dried, cleaned carefully with horse brushes and then with hand house brooms. Hot tar was then spread with special brushes, the road covered with sand and traffic let on. The cost on the low English basis of labor, tar, sand and heating, was a little more than 2 cents per square yard per treatment. The treatment must be repeated twice the first and once per year thereafter. The results are promising, but not yet conclusive.



A New Type of Pier for New York Harbor.

The tests of tarring made in connection with the U. S. Office of Roads at Jackson, Tenn., in 1905, give interesting data for that locality. In addition to the quantity of special tar used (contributed free) and the cost of labor, Mr. Howard estimates the cost of the special tar on the basis of the cost of Tarvia, which was the material used. It is a specially prepared tar free from water, light volatile oils and of a uniform standard. It is not patented and can probably be made by experts. All costs considered, the cost of 0.45 gal. per square yard and of labor, heating and sand, was an average of $0.04012. Freight on tar and superintendence added makes a total cost of a little above 6 cents per square yard for the first tarring. It penetrated about one inch into the macadam and at the end of seven months was in good condition. To remain constantly good it should have been all re-tarred in 1906. Parts, however, were re-tarred in October, 1906, and when examined in January, 1907, were excellent. The road produces practically no dust, is waterproof and smooth.

Near Troy, N. Y., the State engineer in 1906 tarred a section of road. He cleaned the road, spread hot tar, covered it with screenings, consolidated it with traffic and repeated the operation twice. He used special tar from which the water had been boiled off and the result thus far is promising.

A few of the necessary principles to observe in tarring macadam are the following: Before tarring the macadam must be brought to grade and then filled with fine stone screenings, rolled and subjected to traffic about a month or until consolidated and firm. The mechanical bond of the macadam should be as perfect as possible and not rely upon the prepared tar to do the binding as already described. Crude tars must not be used as they contain water ammonia and sometimes other objectionable substances according to their origin. If crude tars are purchased they must be prepared by the buyer. It is probably best to get one or more of the prepared tar products of which the one mentioned is a type, or some tar product which fulfills the physical and chemical properties needed. These properties can be determined by an expert familiar with them.

The work should be done only in warm and dry weather. The macadam should be first swept clean and sometimes washed, if possible, but should be allowed to become perfectly dry to a depth of at least 1 in. before applying the tar. The tar should be spread uniformly under competent supervision. It should be allowed to stand and percolate for at least several hours after being spread and then be covered preferably with sand or with uniform fine-grained stone screenings, containing no earthy matter or dirt. The tar should be applied at about 200° F. After the sand or screenings have been spread it is best to wait several hours before rolling with a steam roller. During the rolling additional sand or screenings must be added if any tar squeezes up through them. It is a good plan to keep traffic off the finished road for a short time after rolling, because the work is done in warm weather and it is wise to let the tar continue to penetrate and become cool before traffic is permitted.

A study of sections of roads which have been tarred convinces Mr. Howard that the tar at the surface of the road is oxidized by the air and other elements and leaves its adhesive ingredients, such as anthracine, paraffin and naphthaline, in the road surface, and the softer oils below remain to give life to the lower strata. Because this oxidation takes place the road is hardened and made more durable. In time, as stated, the tarring must be repeated to supply new life. It pays in every sense to keep tar-treated macadams clean, because accumulations of leaves and dirt, brought upon it, disintegrate the road, although not so much as ordinary macadam not tarred.

Each locality is a separate problem as to what available materials to use for constructing roads and what methods to adopt for reducing dust. His experience in testing materials in the laboratory and constructing pavements and road surfaces in many places, convinces Mr. Howard that not cheap first cost, but economic maintenance is true economy. This applies also to suppressing dust. Water, alone or mixed with salts or with alkali and oil, has a very limited application. Certain adhesive asphaltic oils for soft road materials and specially prepared coal tar products for hard macadam and similar roads, seem to be the present solutions of dust problems for thousands of miles of highways.

The New Piers in South Brooklyn.

In its design for nine new piers on the South Brooklyn water front the Department of Docks and Ferries of New York City has introduced a novel type of construction, the result of much study made under the direction of Commissioner Bensel, by Mr. C. W. Staniford, engineer-in-chief. Some of these piers are 1,200 ft. long by 150 ft. wide, with 250-ft. slips. Very shoal water exists over the whole section where they will be constructed, and it will be noticed that the adopted plan makes it necessary to carry out only the minimum amount of dredging to secure a depth of 35 to 40 ft. at mean low water without endangering the pier construction. While other piers have been built with solid-filled inside sections, they have relied for their side support on perishable wooden sheet piling for retaining the filling. In these new piers the sheet piling is replaced by a concrete retaining wall which surrounds the whole structure and is built on piles cut off below low water. This makes the whole pier for a width of 75 ft. in the center absolutely permanent and with a substantial paved surface. The sides will be finished with reinforced self-supporting concrete slabs for the decks, the design of this part of the pier eliminating much of the timber found in previous designs, and all of the timber can be renewed at a small cost in the future without disturbing the concrete deck. It will be noticed in the illustrations that the natural bottom is dredged out on a slope on each side of the central portion of the pier and this slope is protected by a mass of rip-rap and cobble. The concrete retaining walls are tied together by means of 2-in. steel rods with turn-buckles, and the portions of the pier platform outside them are carried by two 6x12-in. timbers capping each bent of piles. The diagonal and horizontal braces below these caps are of 5x10-in. timbers.

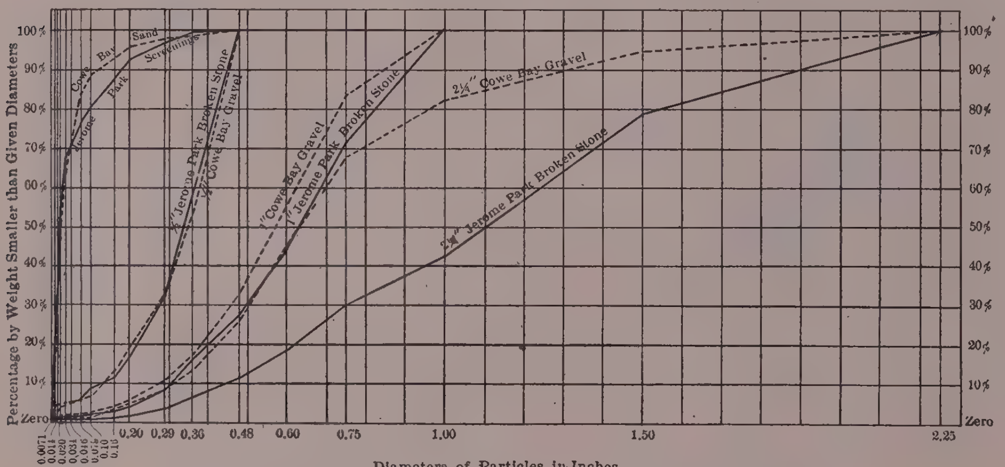
The type of shed over these piers is also new in this vicinity. The roof is carried by two rows of columns supported directly on the concrete retaining wall, which thus obviates the necessity of any extra piles to take care of the shed load. The spaces between the columns and the sides of the pier are roofed over by the cantilever projections, the trusses carrying at their outboard ends the doorways which are necessary for handling large steamer traffic.

The Construction Uses of Electricity are well shown on a number of the works undertaken by the U. S. Reclamation Service, the latest of these being what is known as the Strawberry Valley project near Vernal, Utah. A temporary power house will be erected some 33 miles from the construction camp, and power transmitted from it electrically for building operations. The equipment in this temporary station will include two 425-kw., General Electric, three-phase alternating-current generators directly connected to Leffel water wheels. The generators will furnish current at 11,000 volts to transformers which will raise the voltage to 22,000 for transmission. Two 45-kw. generators will be used for exciting purposes. Current is furnished to two sub-stations, equipped with motor-generator sets.

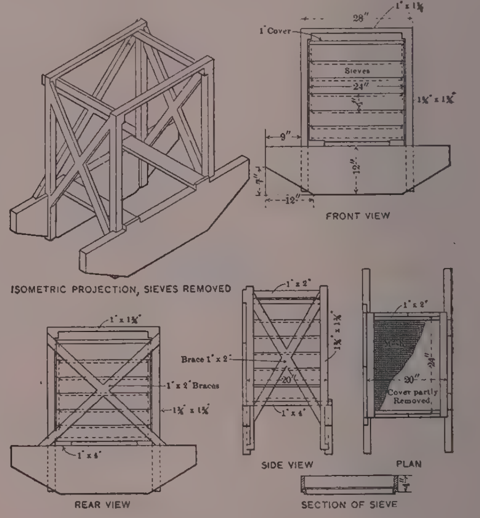
The Laws of Proportioning Concrete.

An important paper on the "Laws of Proportioning Concrete," written by Messrs. Wm. B. Fuller and Sanford E. Thompson, was presented by the latter at a meeting of the American Society of Civil Engineers on April 17. The paper was printed in the "Proceedings" of the Society, Vol. 33, page 222, but Mr. Thompson gave considerable information when it was presented, supplementing the more important sections. His statements were so interesting that they are reprinted here with several illustrations not published in the paper.

Experiments made by one of the authors at Little Falls, N. J., in 1901, on the density and transverse strength of concrete beams mixed in various proportions, indicated that the strength of concrete varies with the percentage of cement contained in a unit volume of the set concrete, and also with the density of the specimen. With the same percentage of cement in a given volume of concrete, the densest mixture, irrespective of the relative proportions of the sand and stone, was in general the strongest. The Little Falls tests further indicated that, for the materials used, there was a certain mixture of sizes of grains of the aggregate which, with a given percentage, by weight, of cement to the total aggregate, gave the highest breaking strength. In practice, also, it was found that the concrete made with this mixture worked most smoothly in placing.



Average Mechanical Analyses of Various Natural Materials.



Frame for Sieves.

These results were brought to the attention of the Aqueduct Commission of the City of New York in 1903 by Mr. J. Waldo Smith, then chief engineer for the Commission, and at his suggestion the Commission authorized a further study of these and related matters. The experiments were conducted at Jerome Park Reservoir, then under construction. The tests were arranged with the view to ascertain the effect of different aggregates upon the density, strength and permeability of concrete, and particularly to determine the exact sizes of aggregate which, mixed together with a given proportion of cement, would form the best concrete. It also became necessary to study many related subjects, such as the physical characteristics of different cements, broken stone, broken stone screenings, gravel and sand, especially with reference to specific gravity, weight, voids and density. Each material was tested by itself and when mixed in various proportions with others.

The experiments were begun with a series of tests of the density of different mixtures of aggregates and cement, to study the laws of proportioning for maximum density with different materials, and these density experiments were followed by the manufacture of concrete beams for comparing the laws of strength with the laws of density and determining the relation between these two qualities. As the compressive strength of concrete is a truer measure of its quality than the transverse strength—which in the case of concrete is really one form of tension test—two pieces of each beam after being broken in the beam machine were capped with neat cement so as to form prisms, and these were tested for compressive strength; a number of them were also tested for the compressive modulus of elasticity. A selected number of pieces of the broken beams were also tested for permeability.

A number of conclusions have been drawn from the tests. Many of them introduce laws which the writers believe have not hitherto been recognized and are opposed in certain cases to current ideas. Although based upon experiments with but two aggregates, these were so characteristic as to make the various comparative results of nearly general application.

These conclusions are stated at the beginning of the paper as printed in the "Proceedings," and to avoid repetition they will be given here merely in connection with the diagrams illustrating them. For details reference may be made to the printed paper.

For the density, or volumetric tests, which were preliminary to the beam experiments, nearly 400 trial mixes of aggregates were made. These were composed of particles of various sizes, following a logical plan, and containing first 10 per cent. of cement to the total weight of the dry materials and then other percentages of cement. The materials for each specimen were weighed separately and mixed with water to the same medium-wet consistency, and the resulting volumes thus obtained from exactly the same total weight of dry materials (corrected for specific gravity) were compared.

In the first place, it was the aim to determine for the various materials under consideration, artificial mixtures of aggregates graded in size by methods of mechanical analysis which would give concrete of maximum density. These ideal mixes having been determined, the concrete made from them could be compared, with respect to density, strength and permeability, with concrete made from simple mixtures of natural materials, and the best proportions to use upon active construction work could be fixed.

Two classes of materials were used for the aggregate: broken stone and screenings from the crushers at the reservoir, and Cow Bay gravel and sand dredged from the river.

Most of the experiments were made upon the same proportions; namely, 10 per cent. by weight, of cement to the total dry materials, thus corresponding to proportions 1:9 by weight. In the earlier tests mechanical analysis mixtures were made to definite curves, such as parabolas and straight lines and curves intermediate between these, in order to select the curve giving the maximum density. In the later tests, in the winter of 1904-5, the methods were changed slightly, and the best results were obtained by making mixtures on trial curves without reference to their mathematical equations, and then, having found the best curves, equations were fitted to them, so that they could be more easily applied to different materials and more readily plotted.

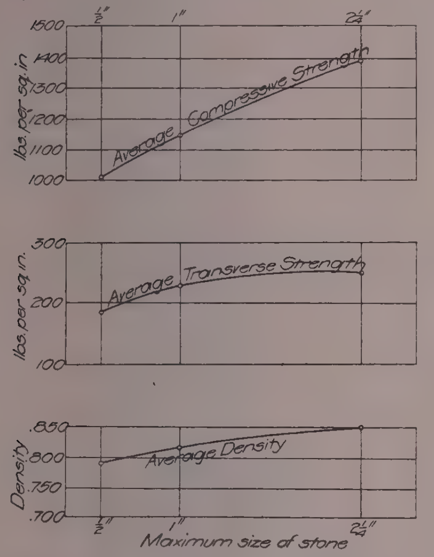
In all the tests, instead of following the more usual plan of testing the aggregates separately, every experiment was performed with a mixture of the aggregate and the cement gauged with the water necessary to produce the proper consistency.

The necessity may be questioned for using cement in the tests for density, which were really for the purpose of determining the best proportions of the various sizes of particles of the aggregate. Why would it not have been simpler to use only the dry aggregate with no cement or water, and thus more readily obtain the mixtures which would give the least volume with the same weight? As a matter of fact, both theory and experiment prove that the mixtures of aggregate which give the greatest density when dry do not necessarily give the greatest density when mixed with the cement and water. The cement and water actually occupy space in the mass, as many of the voids are too small for the grains of cement to fit into them without expanding the volume, and the water surrounds the grains of fine sand and cement and actually increases the bulk. As an illustration of this, the weight per cubic foot of very fine sand when loose, if weighed absolutely dry, is very nearly the same as the weight per cubic foot of a very coarse sand weighed dry. However, if the two sands are mixed with cement and water, the resulting mortar made with the fine sand will occupy a bulk perhaps 20 per cent. greater than the mortar of coarse sand, even when each of them is mixed with the cement in the same proportion by weight or by absolutely dry volume. The density of the mortar of fine sand will be correspondingly less than the mortar of coarse sand. Furthermore, the proportion of cement to sand affects the relative bulk and density of the two mortars, 1:1 mixtures giving different comparative results from 1:4 mortars.

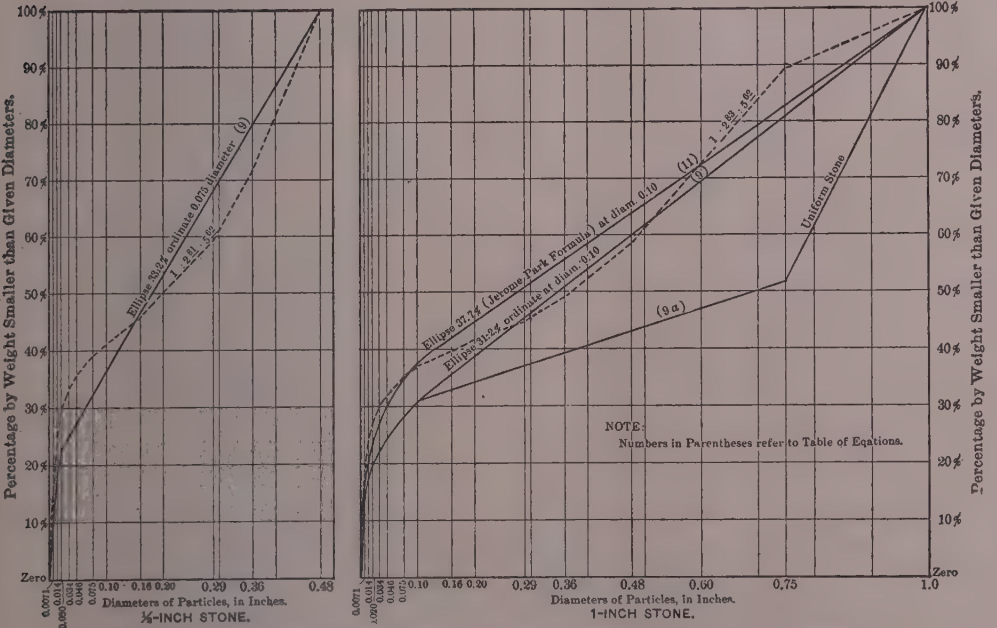
For the density tests and the beams the stone and screenings were separated in the laboratory by 21 sieves ranging in size from 3-in. openings to No. 200 mesh, the latter corresponding to an opening of 0.0027 in. By using different mixtures of the sizes separated by these sieves, it was possible to obtain an infinite variety of proportions.

The diameters of particles, with the corresponding commercial sieve numbers used in this series of tests, are shown in the following table:

Normal sizes of sieves.	Diameters passing sieves.	Commercial numbers of sieves.	Diameters passing sieves.
2.25 in.	2.25 in.	No. 10 in.	0.075 in.
1.50 "	1.50 "	No. 15 "	0.046 "
1.00 "	1.00 "	No. 20 "	0.034 "
0.75 "	0.75 "	No. 30 "	0.020 "
0.60 "	0.60 "	No. 40 "	0.016 "
0.45 "	0.48 "	No. 50 "	0.014 "
0.35 "	0.36 "	No. 74 "	0.0071 "
0.27 "	0.29 "	No. 100 "	0.0058 "
0.20 "	0.20 "	No. 150 "	0.0036 "
0.15 "	0.16 "	No. 200 "	0.0027 "
0.10 "	0.10 "		



Density and Strength of Concrete with Aggregates of Different Size.



½-INCH STONE.

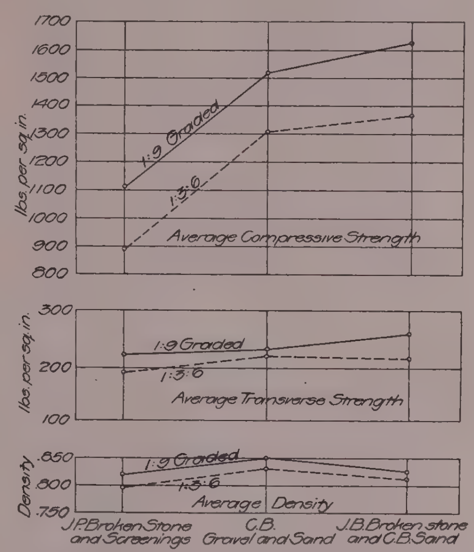
1-INCH STONE.

Mechanical Analyses of Mixtures of Cement, Sand and Stone for Beams.

The separation of the aggregate into these sizes was made with large sieves about 18x24 in. square, arranged in tiers on rocker frames, as shown in the illustration. The aggregates when screened were labelled according to the size of sieve which was passed, and stored in bins and drawers ready for the volumetric tests.

An accompanying diagram shows the mechanical analysis curves of the three sizes of stone and gravel and also the sand and screenings used in the experiments. Mechanical analysis consists in separating the particles or grains of a sample of any material, such as broken stone, gravel, sand or cement, into the various sizes of which it is composed, so that the material may be represented by a curve, each ordinate of which is the percentage of the weight of the total sample which passes a sieve having holes of a diameter represented by the distance of this ordinate from the origin in the diagram. To illustrate with the 2½-in. Jerome Park broken stone in the diagram, the curve indicates that all of the samples screened, or 100 per cent., passed the 2.25-in. mesh; 78 per cent. passed the 1.50-in. mesh; 42 per cent. passed the 1-in. mesh, and so on.

The objects of mechanical analysis curves, as applied to concrete aggregates, are: (1) To show graphically the sizes and relative sizes of the particles. (2) To indicate what size particles are needed to make the aggregate more nearly perfect and so enable the engineer to improve it by the addition or substitution of another material. (3) To afford means for determining the best proportions of different aggregates.



Properties of Concrete with Graded Aggregates and 1:3:6 Mixture.

It is very easy when one has mastered the general principle involved to combine the analyses of two or more materials and form the curve of the mixture. The curves are extremely useful in practice for comparing different aggregates and combinations of aggregates for proportioning concrete. In the present series of studies, as a result of the volumetric tests, ideal mechanical analysis curves were determined for each material experimented upon, and equations of the curves, which are given in the paper, were evolved. The best form of curve for all materials was found to be one resembling a parabola, or more accurately, a combination of an ellipse and a straight line.

As soon as the results of the density tests were available in 1905, a series of beams was made up according to definite plans, to compare the strength of concrete made with different materials and different proportions of the various diameters of particles. Cement and aggregate, graded by the curves of mechanical analysis, which were found by the volumetric tests to produce concrete of maximum density for a given kind of material, were used as a basis for the tests, each specimen being composed of 21 sizes of aggregate in the required proportions by weight. The proportionate weights of aggregates to use in each experiment were obtained from curves previously drawn, several of which are illustrated in an accompanying diagram.

Average curves of density, transverse strength and compressive strength of mixtures of cement and aggregates of different maximum size are shown in an accompanying diagram. From the tests the following conclusions were reached:

1. Stone of the largest maximum size makes the strongest concrete under both compression and transverse loading. A concrete in which the graded aggregate runs to 1 in. in maximum size will require for equal strength about one-sixth more cement, and with an aggregate running to ½ in. maximum size about one-third more cement, than concrete with an aggregate in which the maximum size is 2¼ in.

2. The largest stone makes the densest concrete. Concrete made with graded stone having a maximum diameter of 2¼ in. is noticeaby denser than that with 1-in. stone, and this is denser than that with ½-in. stone.

An accompanying diagram gives the comparative density and strength of concrete made with Jerome Park broken stone and screenings, Cow Bay gravel and sand, and Jerome Park broken stone and Cow Bay sand. The proportions are 1:3:6 by weight, correction being made in the gravel for its different specific gravity. Although the density of the mixture of gravel and sand and cement is the greatest, the strength is less than the broken stone and sand mixture. The broken stone screenings give the lowest density and also the lowest strength. The conclusions reached were:

3. Round material like gravel, under similar conditions, gives a denser concrete than broken stone.

4. Sand produces a denser concrete than screenings of similar size grains.

5. A concrete with an angular coarse aggregate, such as broken stone, is stronger than one with a rounded aggregate, like gravel, although the rounded aggregate produces greater density—thus indicating a stronger adhesion of cement to broken stone than to gravel. However, if the sand is also angular, like screenings, but with its grains of the same sizes as the sand, the concrete with both rounded coarse and fine aggregate is the stronger, probably because of its greater density.

The diagram last mentioned also illustrates the higher density and strength of the specially graded mixtures, from which it was concluded:

6. Aggregates in which particles have been especially graded in sizes so as to give, when water and cement are added, an artificial mixture of greater density, produce concrete of higher strength than mixtures of cement and natural materials in similar proportions. The average improvement in strength by artificial grading under the conditions of the tests was about 14 per cent. Comparing the tests of strength of con-

crete having different percentages of cement, it is found that for similar strength the best artificially graded aggregate would require about 12 per cent. less cement than like mixtures of natural materials.

Other conclusions which are referred to more in detail in the paper, but of which no curves have been drawn, apply more especially to the grading of the particles.

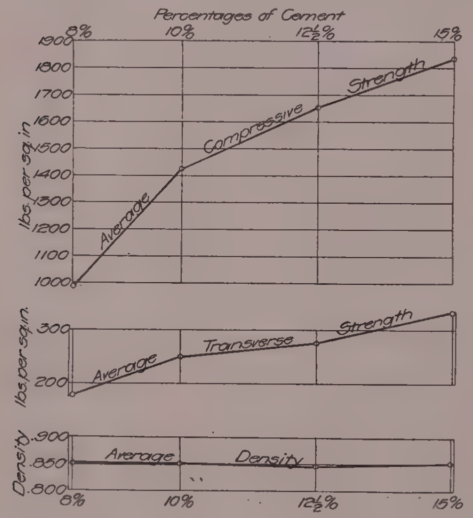
7. The strength and density of concrete are affected but slightly, if at all, by decreasing the quantity of the medium-size stone of the aggregate and increasing the quantity of the coarsest stone. An excess of stone of medium size, on the other hand, appreciably decreases the density and strength of the concrete.

8. The strength and density of concrete are affected by the variation in the diameter of the particles of sand more than by variation in the diameters of the stone particles.

9. An excess of fine or of medium sand decreases the density and also the strength of the concrete, as will also a deficiency of fine grains of sand in a lean concrete.

10. The substitution of cement for fine sand does not affect the density of the mixture, but increases the strength, although in a slightly smaller ratio than the increase in the ratio of cement. This last conclusion is illustrated in an accompanying diagram, showing the uniform density of mixtures with increasing percentages of cement and consequently increasing strength.

11. It follows from the foregoing conclusions that the correct proportioning of concrete for strength consists in finding, with any percentage of cement, a concrete mixture of maximum density, and increasing or decreasing the cement by substituting it for the fine particles in the sand or vice versa. This very important law requires further tests for confirmation, outside of the limits of the present tests.



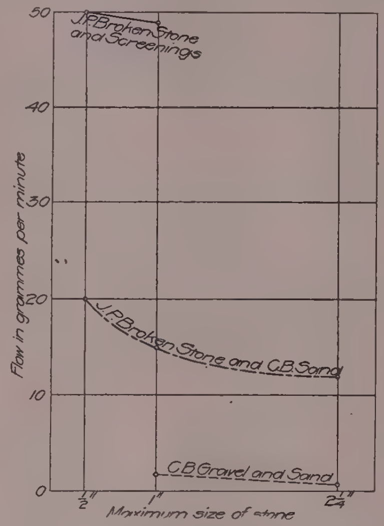
Density and Strength of Concrete with Different Percentages of Cement.

12. In ordinary proportioning with a given sand and stone and a given percentage of cement, the densest and strongest mixture is attained when the volume of the mixture of sand, cement and water is so small as just to fill the voids in the stone. In other words, in practical construction, use as small a proportion of sand and as large a proportion of stone as is possible without producing visible voids in the concrete.

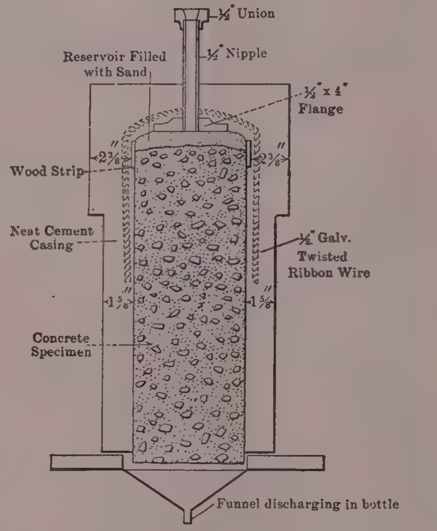
13. The best mixture of cement and aggregate has a mechanical analysis curve resembling a parabola, which is a combination of a curve approaching an ellipse for the sand portion, and a tangent straight line for the stone portion. The ellipse runs to a diameter of one-tenth of the diameter of the maximum size of stone, and the stone from this point is uniformly graded.

14. The ideal mechanical analysis curve, i. e., the best curve, is slightly different for different materials. Cow Bay sand and gravel, for example, pack closer than Jerome Park stone and screenings, and therefore require less of the size of grain which the writers designate as sand.

15. The form of the best analysis curve for any given material is nearly the same for all sizes of stone, that is, the curve for ½-in., 1-in. and 2¼-in. maximum stone may described by an equation with the maximum diameter as the only variable. In other words, suppose a diagram in which the left ordinate is zero, and the extreme right ordinate corresponds to 2¼-in. stone, with the best curve for this stone drawn upon it. If, now, on this diagram the vertical scale remains the same, but the horizontal scale is increased two and a quarter times, so that the diameter of 1-in. stone corresponds to the extreme right-hand ordinate, the best curve for the 1-in. stone will be very nearly the one already drawn for the 2¼-in. stone. The chief difference between the two is that the larger size of stone requires a slightly higher curve in the fine sand portion.



Permeability of Concrete with Aggregates of Different Sizes.



Permeability Test Specimen.

It follows from this last conclusion that, from a scientific standpoint, the term "sand" is a relative one. With 2¼-in. stone, the best sand would range in size from 0 to 0.22 in. in diameter, while the best sand for ½-in. stone would range in size from 0 to 0.05 in. in diameter.

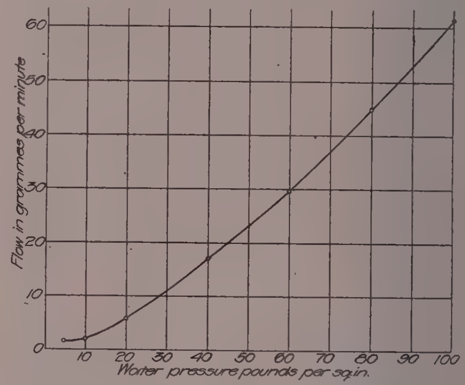
Permeability tests were made on a number of the specimens by coating pieces of beams broken in the testing machine with neat cement, and forcing water through a ring of about 18 in., as shown in the accompanying drawing. Several interesting comparisons were obtained from the permeability tests, although a number of them, especially those with the Jerome Park stone and screenings, were somewhat erratic because of the difficulty of making perfect specimens with this angular material.

The accompanying diagram shows the quantity of water passing through specimens containing different percentages of cement. The conclusion is reached that:

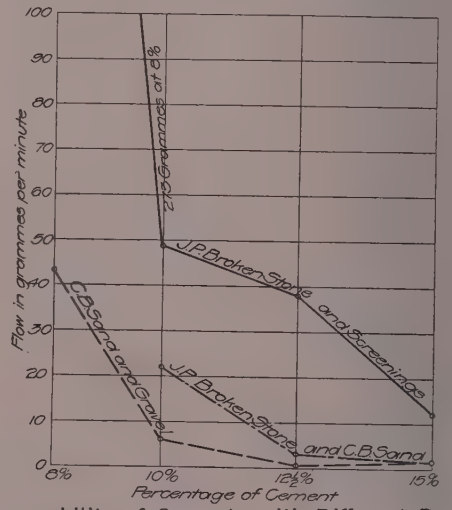
17. The permeability or flow of water through concrete is less as the percentage of cement is increased, and in very much larger inverse ratio.

The effect of different maximum sizes of the stone upon the permeability is shown in an accompanying diagram. The conclusion is reached that:

18. The permeability is less as the maximum size of the stone is greater. Concrete with maximum size stone of 2¼-in. diameter is, in general, less permeable than that with 1-in. maximum diameter stone, and this is less permeable than that with ½-in. stone.



Increase of Permeability with Pressure.



Permeability of Concrete with Different Percentages of Cement.

The conclusion is reached from the same diagram that:

19. Concrete of cement, sand and gravel is less permeable than concrete of cement, screenings and broken stone; that is, for equal permeability, a slightly smaller quantity of cement is required with rounded aggregates like gravel than with sharp aggregates like broken stone.

20. Concrete of mixed broken stone, sand and cement is more permeable than similar concrete of broken stone, screenings and cement; that is, for water-tightness, less cement is required with rounded sand and gravel than with broken stone and screenings.

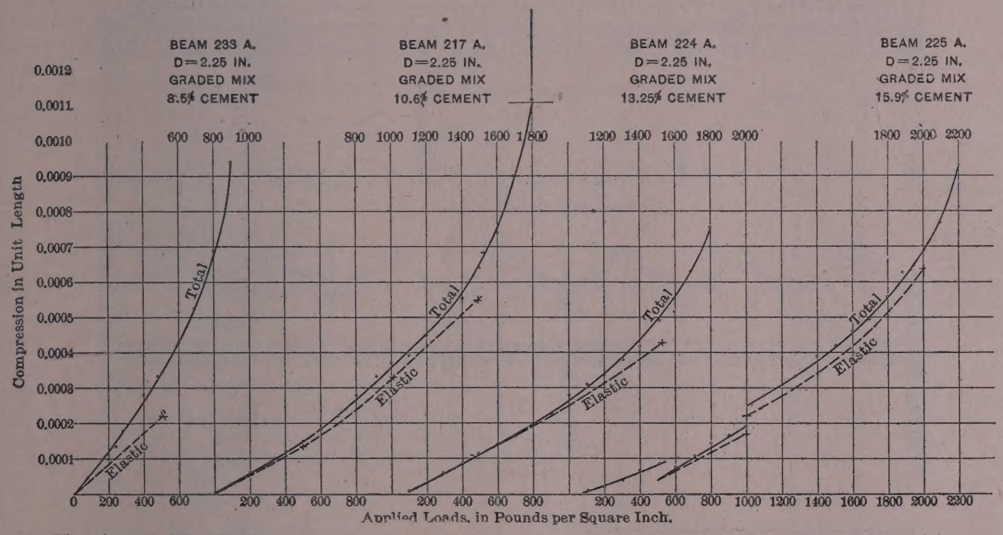
The next curve shows the increase of flow with pressure. Other tests not shown in the diagram illustrate the effect of age and thickness of concrete, so that the conclusion is reached:

21. The permeability decreases materially with age; increases nearly uniformly with the increase

in pressure; and increases as the thickness of the concrete decreases, but in a much larger inverse ratio.

During the progress of the experiments at Jerome Park frequent tests were made of the density of the cement which was being used and also of the densities of various mortars. For this purpose a volumetric cylinder apparatus was used. It was found that when sand is mixed with the cement there is much less variation in the volumes of the mortars due to different percentages of water than in neat pastes, but the variation is generally very appreciable, although less with coarse than with fine sands.

The resulting volumes of different concretes, of the same materials and proportions but with varying percentages of water, are nearly constant, provided sufficient water is added to permit thorough compacting. When an excess of water is used, it is nearly all expelled as the solid materials settle by gravity. There is, however, a slight variation even in concrete. A dry mixture, provided sufficient water is added to rise to the top on hard ramming, can be compacted somewhat more than a concrete of medium consistency, while a very wet concrete is apt to occupy a very slightly larger volume, and hence be less compact than a medium concrete. In most cases, the difference between the medium and very wet mixtures is only noticeable by extremely accurate measurements.



Total and Elastic Compression of 6x6x18-in. Prisms of Cement, Sand and Gravel.

A few of the specimens were also submitted to tests for elasticity and the series showing the effect of increasing the percentage of cement in 6x6x18-in. prisms of cement, sand and gravel is illustrated in an accompanying diagram. Comparisons of the curves in this series and the curves of other tests indicate: 1. The modulus increases with the maximum size of stone. 2. The modulus increases with the percentage of cement. There are one or two exceptions to this rule, but the general trend is unquestionable. 3. In general the modulus of the Cow Bay gravel and sand is higher than the modulus of similar specimens mixed with Jerome Park stone and screenings. 4. The modulus of specimens with a mixture of Jerome Park stone and Cow Bay sand is in general slightly lower than similar specimens of straight Cow Bay material.

THE LOSS OF WATER in the irrigating canals of the Punjab, India, has recently been receiving much attention. According to Mr. J. Davis, Under Secretary of Public Works of New South Wales, who recently visited these works, it is now regarded as certain that 20 per cent. of the water is lost in the main and branch canals and 50 per cent. in the distributing canals and in wasteful application, leaving 30 per cent. of actual use.

Independent Water Supply Systems for Fire Protection.

The problem of adequate fire protection for the business districts of Hartford, Conn., is discussed in a report submited to the city council by a committee consisting of Messrs. C. E. Parker, Joseph Buths and J. M. Birmingham, presidents of the boards of fire, street and water commissioners, respectively, and Mr. F. L. Ford, city engineer. From this report the following notes have been taken.

The grouping of so-called fireproof buildings does not materially lessen the danger of heavy loss by fire. Capt. Stephen S. Sewell, Corps of Engineers, U. S. A., estimated that the cost of restoring the fireproof buildings damaged in the Baltimore fire would be not less than 60 per cent. of their original cost. His estimate of the percentage of loss on the various items is as follows: Steel frame, 10 per cent.; outer walls, 50; floor systems, 50; partitions, 90; column coverings, 100; mechanical equipment, 100; trim and finish, 100; office furniture, 100; contents of vaults, 25. Such losses are generally due primarily to fire in adjacent buildings rather than internal fire, by which a properly constructed fireproof building is seldom seriously damaged. Tables of fire losses covering a number of years show that nearly one-third of the loss of the country is due to such exposure.

A table prepared by the National Board of Fire Underwriters shows that between 1820 and 1905 forty-five fires occurred in the United States and Canada in which the loss ranged from $1,850,000 to $168,000,000, the latter being in the Chicago fire of 1871. The total loss in these forty-five fires was $539,850,000 and in each of ten of them the loss was $10,000,000 or over. The frequency and danger of such conflagrations have created a demand for a fire protection system superior to the ordinary municipal water works or to one depending on steam fire engines.

Independent fire protection systems, like those for municipal service, are of two general classes, viz.: gravity and direct pumping. The latter class may be divided into two sub-classes, depending on whether the pumps are on fire boats or in fixed stations on land. Gravity systems usually carry comparatively low pressures, 180 lb. being the highest found by the committee. Newark, N. J.; Providence, R. I.; Lawrence, Mass.; Fitchburg, Mass., and Worcester, Mass., have gravity systems.

Fire boats have been in use for many years along the water fronts of cities on navigable water. In such places the business district is usually near the water front and the laying of mains with fire-boat connections from the water front to the congested districts was a natural outcome. The pressures on these systems are usually between those of gravity and pumping systems. They are costly to maintain because steam must be kept up constantly and they are faulty because of the time lost in getting the boat into position and in filling the pipes, which are usually drained to prevent their freezing. In northern cities ice is a serious handicap to the movements of the boats in winter. Detroit, Mich.; Cleveland, O.; Buffalo, N. Y., and Boston, Mass., have fire-boat systems.

High-pressure systems operated from fixed pumping stations are the most effective, but on account of the high pressures carried, often 300 lb., they are costly and must be very carefully designed and constructed. Philadelphia, New York, Brooklyn, Coney Island, Winnipeg and Toronto have such systems. These various systems have been described in The Engineering Record on the following dates: Cleveland, Milwaukee, Detroit, Buffalo and Boston, Jan. 8, 1898; Philadelphia, Jan. 30 and March 5, 1904; New York, March 25, 1905; Toronto, April 1, 1905; Coney Island, May 20, 1905.

There is little available information regarding the amount of water used at fires. In Boston in 1892 the per capita consumption for fires was determined, partly measured and partly estimated, at 0.10 gal. In Fall River in 1899 the amount similarly arrived at was 0.11 gal. Mr. Folwell in his "Water Supply Engineering," estimates the annual rate per capita for fire purposes at about 0.08 to 0.12 gal. per day. The daily average consumption of water in the Borough of Manhattan, New York, during 1900, 1901, 1902, 1903 and 1904, was 117,000 gal. For the Borough of the Bronx, during the same period, the daily average was 67,000 gal. The consumption per hour at the important fires in these boroughs and in Brooklyn seems to be about 15,000 gal. These figures make it apparent that the amount of water actually required for fire extinguishment is so small as to be almost negligible in planning a water supply for a municipality. The trouble has never been with the supply, but rather with the ability of the plant to concentrate it at the points where it was needed.

The area to be protected at Hartford is about 1.14 square miles and the variation in elevation is nearly 75 ft. In general the buildings are four to six stories high, though there are two seven-story structures and two other buildings of eight and nine stories, respectively. The committee has recommended the construction of a high-pressure pumping plant and a gridiron distribution system made up of extra heavy cast-iron pipes, from 8 to 24 in. in diameter, with special joints similar to those used in the New York high-pressure system, now under construction. Three hundred pounds per square inch is the pressure recommended at the pumps.

To be efficient for a high-pressure fire protection system, the pumping units must be capable of being operated at their maximum capacity in an exceedingly short space of time, and the source of power must be assured practically against everything excepting the direst calamity. The pumping units mostly in vogue for this class of work are: Producer gas engine-driven triplex pumps, illuminating gas engine-driven triplex pumps, electrically-driven turbine pumps, steam turbine-driven turbine pumps.

Plans for two types of pumping plants have been submitted. In one plan seven units, each consisting of a vertical double-acting, triplex pump, capable of delivering 1,800 gal. per minute, driven by a horizontal, four-cycle, twin tandem, double-acting, four-cylinder gas engine, are required. The gas engines would be adapted to operate with either illuminating or producer gas, the producer plant being held in reserve. The producer plant would be of the down-draft type, burning soft coal and consisting of two units with a normal capacity of 1,000 h.-p. each. The gas holder would have a capacity sufficient to operate six engines, developing 2,500 h.-p. for about forty minutes. This would give ample time to put the producers in operation, starting with everything cold. The total estimated cost of such a station, including the site and 10 per cent. for engineering and contingencies, is $377,905, and the estimated cost of operation is $8,648 per year, not including any interest.

The second project contemplates the use of steam turbines operating multi-stage turbine pumps. Nine units would be required and four 1,150-h.-p. boilers. The total estimated cost of such a plant, including the site and a 10 per cent. allowance as before, is $257,620 and the annual cost of operation is estimated as $45,320, not including any fixed charges.

A plant with electrically-driven turbine pumps was impracticable as the central station company would not furnish current.

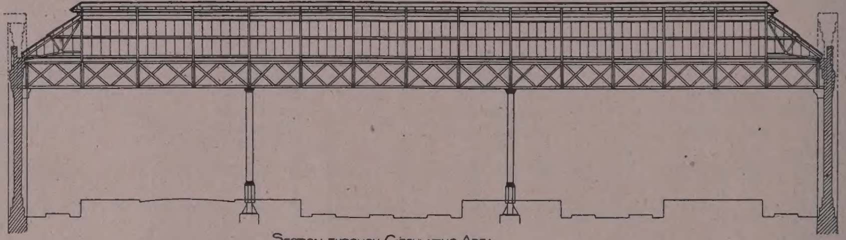
The Maintenance and Obsolescence Charges that should be made against the property of industrial and public service corporations were briefly discussed in this journal on April 27, and it was stated that the items under this head could be variously classified in such a way that a great deal of uncertainty might arise concerning them. A good example of this is the general criticism made on the quarterly report of the U. S. Steel Corporation, which appeared on April 30. Previous reports have represented the earnings as "total net earnings after deducting, each month, renewals and maintenance of plants, employes' bonus funds, and also interest on bonds and fixed charges of the subsidiary companies." The report just made gives the earnings as "total earnings after deducting all expenses incident to operation, including those for ordinary repairs and maintenance of plants, employes' bonus funds, and interest on bonds and fixed charges of the subsidiary companies." It will be noticed that nothing is said about expenditures for renewals, which is attracting attention because the report shows a reduction during the quarter just ended of nearly $2,000,000 in charges for sinking fund, depreciation, special improvement and replacement funds over the amount for the previous quarter, and nearly $2,250,000 over the amount for a year ago. If it is assumed that the differences in phraseology in the report do not signify any different bookkeeping methods from those previously employed, then the report just published shows a loss of $2,600,000 as compared with the preceding quarter and a gain of about $2,500,000 over the corresponding quarter of last year. It is manifest that such uncertainty is extremely undesirable, but it is sure to arise if some standard method of classifying and stating the group of charges referred to is not generally adopted. The matter was recently discussed by a British chartered accountant, Mr. Leake, in a paper read before the Institute of Bankers. He dwelt on the necessity of a proper provision for such wastage expenses in the statements of corporations and suggested a law requiring them to tabulate, in standardized form, the economic life of the various items of plant used in such undertakings, and to set aside each year a certain percentage, calculated on this basis, sufficient to replace the plant entirely at the end of the stated term. Repairs and partial renewals to keep the plant in working order will be paid for in addition, as now. Mr. Leake points out that maintenance out of revenue is insufficient provision for the future. Sinking fund allowances, which are merely for the redemption of borrowed capital, cannot take the place of such a reserve as that suggested, as the plant may become obsolescent long before the date for repayment of the borrowed funds is reached.

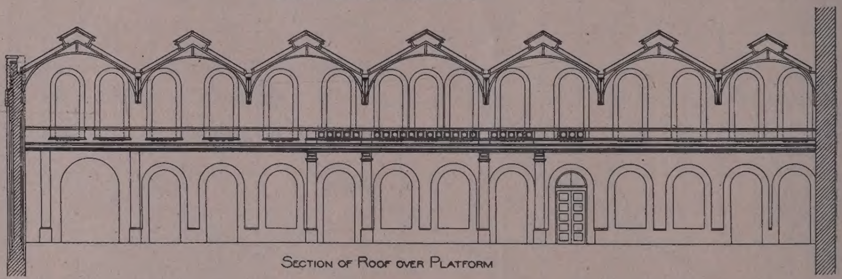
The New Roof Over Charing Cross Terminal Station, London.

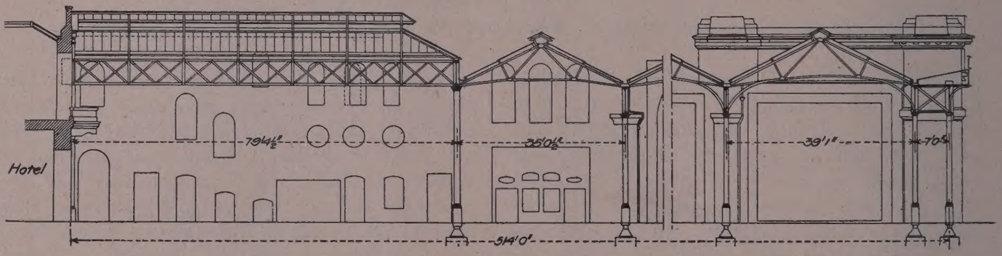
By Charles S. Lake, A. M. I. Mech. E., London.

The Engineering Record of Jan. 13, 1906, published an account of the failure of the roof over the Charing Cross Station of the South-Eastern & Chatham Ry., which occurred on Dec. 5 of the previous year. The roof was fully described on that occasion and the cause of its partial collapse, and the circumstances attending the same, were also carefully recorded, therefore it will not be necessary in the present article—which presents a general description of the new roof, now virtually completed—to occupy space in describing the original structure, or in detailing afresh the facts concerning its demolition.

The accompanying drawings, for the use of which as well as for particulars incorporated in the following description, the writer is indebted to the courtesy of Mr. P. C. Tempest, M. Inst. C. E., chief engineer of the South-Eastern & Chatham Ry., clearly show the general design of the new roofing and the details of the supporting columns.


Section through Circulating Area


Section of Roof over Platform



Sections of New Roof of Charing Cross Station, London.

The roof has a maximum length of 520 ft. and is 166 ft. wide between the side walls of the station. It is comprised of twelve transverse bays over the platforms and seven longitudinal bays over the passenger circulating area. The ends of the bays are hipped except over the circulating area, where they are gabled in order to avoid interference with the station hotel windows—the hotel being situated at the northern end of the station and forming the termination of the roof at that end.

At the southern, or outward, extremity of the station the side walls are finished off with ornamental stone piers, and an ornamental wind screen has been erected at that end. The main feature of this screen will, on completion, be the shield of hammered steel which it will carry, and which will be decorated in the centre with the South-Eastern & Chatham Railway Co.'s coat of arms, the latter executed in enameled iron.

The roof is of the ridge and furrow type throughout, whereas the original structure covered the six platforms and seven roads comprised in the station by one clear span of 166 ft. In order to adapt the new roof to the existing walls, transverse girders spaced about 35 ft. apart are employed, these being supported at the ends by the side walls and at suitable intervals in their length by intermediate steel columns. These girders form the main supports for the principals, which latter as a consequence are of about 35 ft. span.

The height of the underside of the transverse girders above platform level is about 23 ft. A modification of the design has been adopted over the circulating area, where the roof is about 6 ft. higher than over the platforms, and instead of the girders running transversely across the station they here take a longitudinal direction north and south and the space below is left clear of obstruction from the columns. The roof principals in this portion of the structure are of about 26 ft. span, and consist of trusses, the lower members of which are arched as seen in the cross-sectional drawing taken through the circulating area. The principals of the main roofing over the platforms consist mostly of simple trusses, except in the case of those which come directly over the columns, where the underside member of each principal has been arched to stiffen the construction and at the same time a pleasing appearance is imparted to this portion of the design. The columns supporting the roof rest on cement concrete foundations consisting of blocks 5 ft. square, which are built on the piers of the arches forming the viaduct on which the station stands. The columns themselves are of rather novel design and should certainly prove very effective.

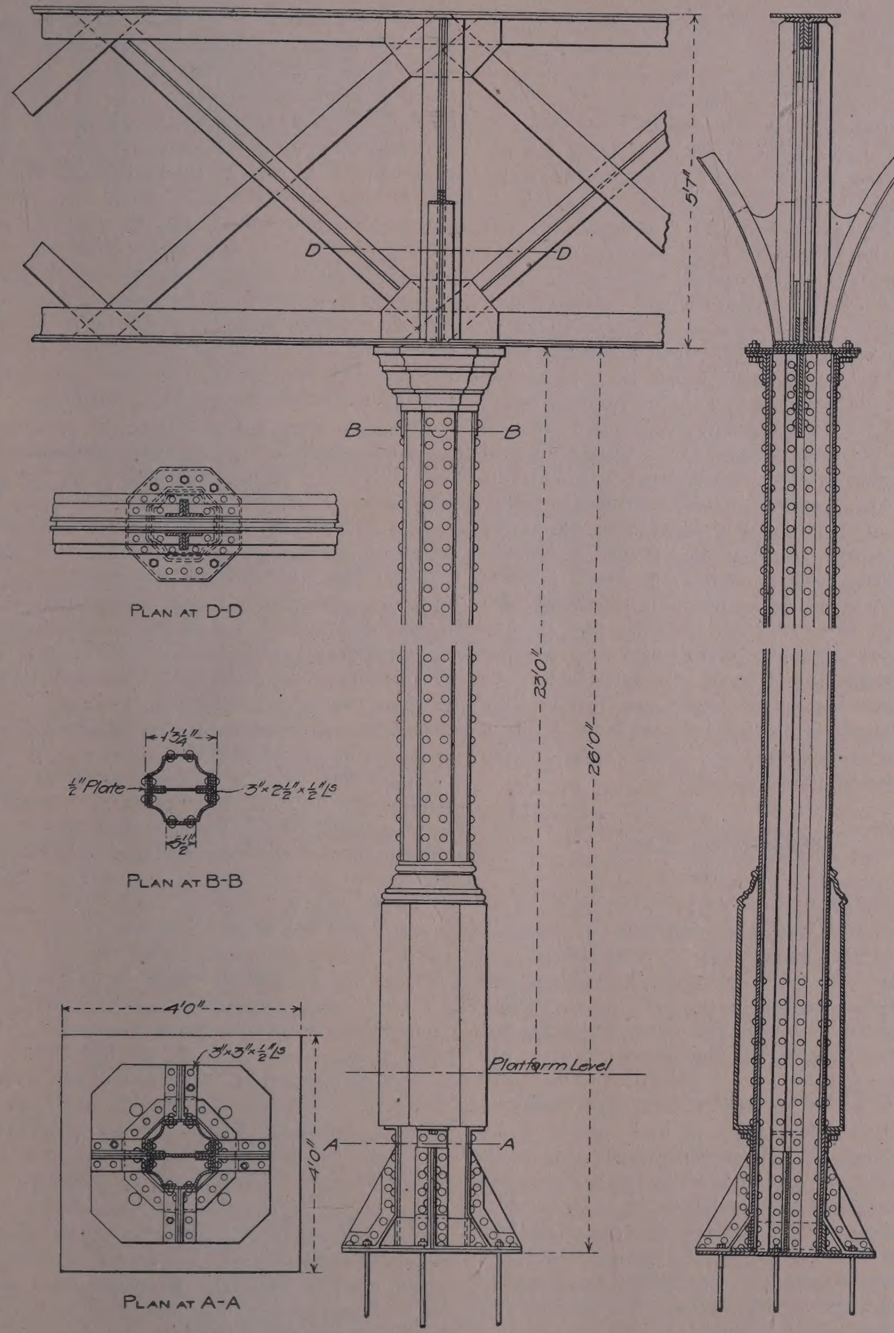
They are of fluted octagonal section and are built up of four 5½x½-in. flat bars connected together by four pile-section channels. The base of each column is surrounded by a loose cast-iron ornamental plinth standing about 3 ft. 6 in. high above the platform, whilst the top of each column is finished off with a cast-iron molding also of ornamental design. The columns are of steel throughout, riveted up, except of course the base plinths, which are of cast iron. Each column weighs about 3 tons complete.

The transverse girders are of the continuous lattice type, as seen in the drawings, and are 5 ft. 6 in. deep over main angles. They are entirely of mild steel. The booms are composed of 14x½-in. plates and two 6x3x½-in. tees.

The glazing of the roof, which has an area of about 2 acres, has been done on Mellowes patent system. Lantern roofs are formed at the apex of each bay for ventilating purposes, and these, except over the circulating area, are covered with Uralite on close boarding. Additional ventilation is secured over the circulating area by raising the top length of glazing above the lower one and overlapping at the junction, thus forming a 4-in. air space between the two glazings. An open space has also been left down the center of the roof, and altogether about five times the amount of ventilation which existed in the old roof has been provided in the new one.

A great deal of attention has been given to the guttering. All of this has been made of cast iron ½ in. thick, 18 in. wide and 6 in. deep, thus insuring by its large area, the removal of accumulated dirt, which, with an atmosphere like that of London, is a matter requring full consideration. Snow gratings made of creosoted timber will be placed over the valley gutters, and smoke plates consisting of close boarding and Uralite will be suspended from the girders over the running roads to protect the steel-work and assist in dispersing the fumes rising from the chimneys of locomotives standing underneath. The smoke plates are hung 4 ft. above the top of the engine chimneys.

The new roof in its design and construction embodies the most modern ideas for this type of structure. It has been designed to combine strength and stability with simplicity of detail and maximum efficiency. It is pre-eminently of graceful appearance, and is of course immeasurably superior, from a maintenance point of view, to the one it supersedes. About 1,000 tons of steel-work are comprised in the construction of the roof, and it has taken about 5½ months to complete. No interference with the traffic of the station has been necessary during the erection and no mishap has occurred. The design is that of Mr. P. C. Tempest, M. Inst. C. E., who has also superintended the work of erection, being represented on the site by his resident engineer, Mr. G. Ellson, A. M. Inst. C. E. The steel-work was first painted with two coats of Dixon's silica-graphite paint and after that it received two coats of dark stone-color lead paint, the caps and bases of columns being picked out light gray. The chief contractors for the supply and erection of the steel-work were Messrs. Handyside & Co., Ltd., of Derby and London.



Details of Columns of Charing Cross Station Roof.

Book Notes.

Most people enjoy sitting in front of an open fireplace and for this reason a little book by Mr. G. C. Gillespie, entitled "Rumford Fire Places and How They Are Made," will probably interest many readers. The body of the book is Count Rumford's famous essay on proper fireplace construction. This is written in the style which has proved so delightful to many readers of the eminent physicist's other writings and the numerous illustrations of fireplaces which have been collated by Mr. Gillespie for use in illustrating the volume make it a very attractive book for the householder as well as the architect. A short introduction which he has contributed makes the subject entirely clear even to a reader who knows nothing whatever about the details of building construction. (New York, William T. Comstock, $2.)

Prof. C. H. Benjamin is well known among the foremost writers on machine shop practice in this country, and accordingly his book on "Modern American Machine Tools," is certain to receive a warm welcome. It is an excellent description of the leading characteristic of machine tools manufactured in the United States, taken up from the point of view of the purchaser and user rather than that of the apprentice or journeyman. There are many books which tell the machinist how to adjust and operate such tools, but very few which have been written from the standpoint that has been adopted by Mr. Benjamin in this work. In deciding upon the type of machines to be considered the author has thought best to exclude special tools used only for a limited line of products and to include only those machines which find general use in shops. This embraces planing, turning, boring and drilling machinery, milling and grinding machines, and finally machines for shearing and punching metal and tor cutting screw threads. The final chapter is a very interesting review of machine tool design written to show the recent improvements and the direction in which future progress will probably take place. Special praise should be given to the publishers for the admirable illustrations they have furnished, which add materially to the usefulness of the text. (New York, E. P. Dutton & Co., $5.)

The interest in all concrete work is now so marked that it is not at all surprising the excellent manual on "Cement and Concrete," by Mr. L. C. Sabin, has been brought out in a second revised and enlarged edition. When the book first appeared it was reviewed at considerable length in these columns, and consequently it is unnecessary to print an extended notice at this time. It may be stated, however, that it contains a concise summary of the great amount of valuable experimental and practical data accumulated in the United States Engineer Office at Sault Ste. Marie, Mich., and a résumé of data from other reliable sources. All this information has been collated and discussed in a volume which combines scientific accuracy with practical usefulness in an unusual manner. The subject is discussed in four sections, the first devoted to the classification and manufacture of cements, the second to the properties of cement and the methods of testing to determine them, the third to the preparation and properties of mortar and concrete, and the four to the uses of mortar and concrete. Portions of the book have been entirely rewritten in order that the contents may reflect the latest views and contain the latest decisions of the national engineering societies and new sections have been added to make the book a thoroughly comprehensive treatise. It is distinguished from other books on the same subject in containing relatively more information about the properties of materials and less about the methods of using them, although the latter phase of the subject is by no means neglected. Descriptions of many important works built of concrete are given, but the author has not attempted to furnish the details of their design nor has he gone into the minute construction of forms and apparatus used in carrying on construction in concrete. (New York, McGraw Publishing Co., $5.)

It seems to be generally acknowledged among sanitary engineers that the work on "Sewage and the Bacterial Purification of Sewage," by Dr. Samuel Rideal, is the most comprehensive treatise on the subject in the English language. The first edition of this book was noticed at considerable length in this journal, and the appearance of a third edition recently is only natural in view of the high standing which the book has won. The new edition is distinguished from those previously issued in having numerous references to the valuable experience gained during the last five years in bacterial methods of sewage disposal, and also in containing the conclusions of the Royal Commission on Sewage Disposal, so far as they have been published. Although for reasons which have been stated a number of times in this journal, sewage disposal by bacterial methods has received a great deal of attention in Great Britain, nevertheless the actual construction of works has been attended by difficulties due to official regulations that have been extremely irksome. Accordingly, the following note in the preface of the new edition of this book is interesting: "The Local Government Board has relaxed some of the rules which have proved irksome in many districts, but as unfortunately works approved by them and constructed out of loans on deposited schemes, have in certain cases given rise to serious complaints and law suits, I hope that in the future it will be possible in England for authorities to carry out works which are likely to be more successful, if the expert, after or during construction, is allowed to make such modifications in design or working as in his opinion will result in a proper disposal." For the benefit of those who are not acquainted with the volume it may be added that it contains a full statement of the present views of the leading sanitary specialists concerning the character of sewage and the nature and causes of the various changes taking place in it before it is finally reduced to stable substances. After this general review of the scientific features of sewage changes, the author takes up methods of disposal by irrigation, filtration, chemical treatment, sterilization and the numerous bacterial processes by which treatment is effected by a rapid rate on restricted areas of land. He also gives information concerning sewage outfalls and the discharge of sewage into fresh and salt water, the agricultural value of effluents of bacterial plants and the characteristics of many trade effluents. The volume is well illustrated. (New York, John Wiley & Sons, $4.)

A book which will be useful to owners of steam plants where trouble is experienced with scale, foaming or other difficulties, is Mr. W. W. Christie's "Boiler Waters." In the first chapter the author discussed the properties of water and the various substances found in it, and explains some methods of analyzing water, although probably these methods will not be wholly acceptable to chemists engaged regularly in water analysis. The next two chapters are devoted to boiler scale and its effect on heat conductivity, and to the corrosion of boiler plate. The fourth chapter is on feed water and blow-off piping and other tubes connected with boilers. Priming and foaming are taken up in chapter five, and in chapter six the effect of oil and grease in boilers, as well as the methods of overcoming it is discussed. In chapter seven the author gives an explanation of what is meant by the hardness of water and its importance commercially. In the following chapter the use of feed water heaters and economizers is explained and in the ninth chapter there is a discussion of water softening and methods followed in conducting it. The book closes with a collection of miscellaneous tables. The contents may be roughly divided into two portions, those relating to the mechanical engineering features of the subject, which are taken up interestingly and with considerable detail of value to boiler plant owners, and those relating to the chemistry of water purification for boiler purposes. In the latter division the author is not quite so successful, for statements are not always those which would be made by men making a specialty of the chemical treatment of water. This is hardly a defect in the book, however, from the point of view of most of its probable readers, for the subject of boiler water treatment is of interest to a great many people who are neither inclined nor prepared by previous study to appreciate all the minute details of advanced chemical work. The book is marked by a large amount of information from practical sources concerning the design and operation of water purification apparatus and by information adapted for the use of boiler owners. In order that it may be brought up to date, however, it is to be hoped that the next edition will be a little more in keeping with the latest views of water specialists, for there is no reason why the chemical part of a book of this sort should not be as fully up-to-date as the mechanical part. It is unfortunate that no book on boiler waters has yet been produced of which this criticism is not true. (New York, D. Van Nostrand Co., $3.00.)

Letters to the Editor.

Standard Units of Illumination.

Sir: I was very much interested in your editorial on the "Engineering of Illumination" and the place which you make for a standard unit of illumination, which is, as you say, necessary for studying these problems. In spite of the fact that the Illuminating Engineering Society has been in existence over a year, no step has been taken to adopt a standard such as you suggest. The time has been taken up by a discussion and investigation of photometric methods and results with which we are all more or less familiar, and a discussion of the appliances themselves, rather than the proper use to which the light from these appliances should be put. As you very aptly say, "The engineering side of illumination concerns itself primarily with making the best possible use of the means at hand."

The field which has not been gone into in this country and which is of so much importance is the determination of the amount of illumination required for different classes of work; for example, the schoolroom, the drafting room, the shop, etc., so that in any given instance a measurement may be taken and the question at once determined whether the illumination is sufficient, and in laying out new installations a guide to what will be adequate. In many places there is sufficient light and yet insufficient illumination where it is needed; the light may be thrown in one place, or it may light up the top of the room and not the bottom.

It seems to me if the society would address itself to the problem (and the first step would be to adopt a standard), it would fill a sphere of usefulness which will never be gained by academic discussions of the photometer and the efficiency of appliances. If before telling us how we have to do it they would tell us what we have to do we could go more comprehendingly to our task.

Very truly yours, J. F. W. Jost.

The Design of Retaining Walls.

Sir: The article recently printed in The Engineering Record concerning the collapse of a part of the roof vaulting of the Lawrence filter leads me to write a note concerning the liability to failure of some of the forms of concrete retaining walls which are now being advocated. A good many engineers will doubtless agree with me in the belief that the Lawrence accident was due to unbalanced pressures overturning the outer rows of posts as soon as the centers of the bays last finished were removed. I do not believe that a contractor who is also an engineer will remove centers from such vaults until the work has progressed a couple of bays beyond the place where the centers were to be struck. While the roof may remain standing, a contractor is running a big risk to remove the centers in this way, and if it tumbles down he is to blame unless ordered to remove the bracing prematurely.

The same thing has recently come up several times in connection with concrete retaining walls built according to the prevailing fancy in this part of the country. These walls have a practically vertical thin shell or sheet of reinforced concrete, which rests on a footing of the same material projecting a short distance in front of the wall and running a longer distance back from it, the wall and footing being braced together by buttresses at more or less frequent intervals. The design of the walls has always been ample, in those examples I have seen, to resist all the stresses coming upon their parts as separate portions, but in several cases the wall as a whole was certainly held up by good luck rather than any natural stability. In most cases the resistance of these walls to overturning is figured with the assumption that the weight of the backfilling on the rear of the footing acts in a marked degree to insure stability. If that filling were always compact and not likely to contain water which would freeze in winter and produce heavy thrusts, this assumption would be justified, but I am sure that many others besides myself have noticed cases where the filling-in question is extremely loose and is really of little value in preventing overturning. In a case of this nature, therefore, the chances are that the wall will be held up by the reinforcement in many places along its length, the parts in stable equilibrium retaining in this way those which are less stable.

My reason for writing this note is that the type of wall referred to is now so popular that it seems desirable to issue a warning to contractors called upon to build it. Experience has positively shown in my own work that the front bracing of such walls should be left in place just as long as possible. Not only is this desirable for the sake of the concrete itself, but also to give the back filling all possible time to become settled and compact. In addition the contractor will find it to his advantage to run no risks about the weight and proper placing of the backfilling. It is a good deal less expensive to pay for extra care in this part of the work than to remove the wreck of a fallen wall and rebuild it. In such a case the loss must fall on the contractor, unless he files during construction a written objection with the engineer against the orders under which he puts in the backfilling or removes the front bracing of the wall. This suggestion is based on costly experience I don't like to think about. Yours truly,

Richmond, May 6. Contractor.